ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

REPORT NO. 209024

INDEPENDENT MONITOR AUDIT OF THE ENVIRONMENTAL PERFORMANCE OF THE MCARTHUR RIVER MINE – 2008 OPERATIONAL PERIOD

ENVIRONMENTAL EARTH SCIENCES VIC

REPORT TO THE DEPARTMENT OF REGIONAL DEVELOPMENT, PRIMARY INDUSTRY, FISHERIES AND RESOURCES

AUGUST 2009

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EXECUTIVE SUMMARY

Environmental Earth Sciences was appointed by the Northern Territory Department of Regional Development, Primary Industry, Fisheries & Resources (DRDPIFR) in December 2007 to act as the Independent Environmental Monitor to assess the environmental performance of the McArthur River Mine (MRM) operations. The Mine is located approximately 950 kilometres south east of Darwin, Northern Territory, as shown in Figure 1.

The Independent Monitor has been initially engaged for a five-year period to annually audit the systems designed to manage the Mine's environmental performance. This report details the findings and recommendations of the Independent Monitor's audit of MRM's environmental monitoring systems pertaining to the period from October 2007 to September 2008, which is herein referred to as the '2008 Operational Period'. Information outside of the 2008 Operational Period, such as that gained from site inspections undertaken by the Independent Monitor during late 2008 and mid-2009 have also been incorporated into this audit report.

The audit process comprised the following scope of works:

- a review of the environmental assessment and monitoring activities, procedures and systems implemented by MRM in order to maintain compliance with statutory commitments and conditions of operation;
- review and assessment of MRM's technical compliance with their conditions and commitments;
- a review of the audits and assessments undertaken by DRDPIFR to monitor MRM's environmental performance;
- formal environmental risk assessment;
- gap analysis; and
- site inspections undertaken by the Independent Monitor in December 2008 and June 2009.

The areas of audit focus included those that the Independent Monitor considered to be of greatest environmental significance; these included:

- hydraulic performance of river diversions;
- success of revegetation and installation of fish habitat within the river diversions;
- surface water and artificial water monitoring;
- the environmental performance of the Tailings Storage Facility;
- tailings pipeline integrity and design;
- the design and monitoring of the Overburden Emplacement Facility;
- the environmental performance of the Bing Bong dredge spoil ponds; and
- Bing Bong Port facility fugitive dust emissions.

Additional areas of MRM operations will be focused upon within subsequent audits, as the scope of the audit process will be increasingly honed each year.

The Independent Monitor is of the opinion that whilst McArthur River Mine have demonstrated an adequate level of procedural conformance with the stated commitments and conditions, evidence confirming full compliance with these commitments, was in some cases not supplied, not documented, or appeared to be incomplete. As such, various observations were made by the Independent Monitor to recommend improvement measures; these are provided within Section 6.2 . Three significant procedural non-conformances were noted by the Independent Monitor; these related to MRM's commitment to undertake:

- accelerated salt leaching, revegetation, and annual vegetation surveys at Bing Bong Port;
- in-place quality assurance testing of the Overburden Emplacement Facility clay liner; and
- mosquito monitoring procedures (a non-conformance also identified during the previous audit).

It is acknowledged that MRM have provided documented commitments that these non-conformances will be addressed in 2009.

Based on the review of environmental assessments and monitoring activities, as well as the Independent Monitor's site inspections, the following issues are considered to require urgent investigation:

- seepage and structural integrity of the Bing Bong dredge spoil ponds; and
- seepage migration from the Tailings Storage Facility to Surprise Creek and the hazard classification of tailings in Cell 1 and Cell 2.

Although not urgent, the following issues are considered significant and require corrective action to improve MRM's environmental performance:

- fugitive dust emissions at the Bing Bong load-out facility; and
- weed management along river diversion channels and the mine site.

Minor issues that are considered to require medium-term rectification relate to:

- the generation of dust from the Run of Mine Pad towards Barney Creek and its tributary;
- the design and potential recurrence of failure of the drain sump at the base of the Run of Mine Pad;
- the poor condition of asphalted and paved surfaces at the Bing Bong load-out facility;
- inadequate analysis of the accuracy, reproducibility and precision of routine monitoring results collected by MRM. This includes checking field measurements against laboratory results and expected objectives and using a data quality sign-off sheet for quality assurance;
- rapid maintenance of fencing (damaged by annual floods) to improve rehabilitation works; and
- in-place testing of the clay liner of the Overburden Emplacement Facility as part of future Overburden Emplacement Facility expansions.

The Independent Monitor has provided recommendations for improving the environmental performance of the MRM operations in relation to the abovementioned issues: These include:

- ensuring that all monitoring commitments are adhered to, including the monitoring frequency and analytes;
- ensuring that all figures provided in future monitoring and assessment reports prepared by MRM feature all current relevant monitoring points, including seepage abstraction bores near the Tailings Storage Facility;
- enhanced technical interpretation of the spatial and temporal trends of data sets across all areas of study, including “as-built” construction reports for the diversion works and Overburden Emplacement Facility;
- improved rehabilitation works and management, including rapid maintenance of fencing following flood damage, to keep livestock and feral animals off site;
- update the geochemical and geotechnical testing and documentation procedures to reflect the changes in geochemical characterisation and current impacts at the Tailings Storage Facility; and
- undertake immediate and medium-term studies and rectification works in relation to:
    - weed management at the Mine site;
    - drainage and stability of the Bing Bong dredge spoil; and
    - the rate and quality of leachate migration at the Tailings Storage Facility.

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1 INTRODUCTION

1.1 Regulatory requirements and purpose

McArthur River Mining Pty Ltd (MRM) was granted a license to operate as an open-cut mining facility in October 2006 by the (then) Minister for Mines & Energy, the Honourable Mr Chris Natt MLA. As such, a variation was made to the Conditions of Authorisation No 0059-02 for mining leases MLN1121, MLN1122, MLN1123, MLN1124, MLN1125, MLN1126 and MLN582, pursuant to Section 38(2) of the NT *Mining Management Act*. This variation included the provision of an Independent Environmental Monitor under Schedule 2 of the Authorisation 0059-02. The Independent Monitor is required to:

- monitor the environmental performance of the mine by reviewing:
  - environmental assessments and monitoring activities undertaken by the Operator;
  - environmental assessments and monitoring activities undertaken by the Department of Regional Development Primary Industry Fisheries & Resources (DRDPIFR) ; and
- report to the Operator (MRM) and the Department (DRDPIFR) any urgent issues requiring investigation and reporting.

It is the role of the Independent Monitor to consider key indicators of environmental performance including (but not limited to) the following:

- adherence to statutory commitments;
- effectiveness of environmental risk management systems;
- appropriate and effective monitoring procedures, including air, water, waste, structural, biological and sediment monitoring;
- spatial data management including GIS management, manipulation and representation of data;
- water management, including: surface water and groundwater modeling; solute transport models; discharge conditions; catchment water balance modeling; water quality, and water treatment technologies and options;
- hydrologic and engineering assessments relating to the river diversions;
- geochemistry, geomorphology and structural integrity design and reports for major infrastructure such as the river diversions, Tailings Storage Facility, Overburden Emplacement Facility, Run of Mine Pad, and Bing Bong Port dredge spoil; and
- closure criteria, progressive rehabilitation planning and costing, and ecological reconstruction assessments including the implementation, monitoring and management of rehabilitated landforms and the river creek diversions.

The Independent Monitor was not required to review mine safety or “social issues arising from the operation of the Mine in the McArthur River Region”.

1.2 Objectives

The objectives of the Independent Monitor audit are to:

1. review the environmental monitoring and assessment practices undertaken by MRM and DRDPIFR;
2. identify and report urgent issues requiring investigation; and
3. provide an annual audit report to the Minister for Primary Industry, Fisheries and Resources that:
    - o assesses the environmental performance of MRM operations; and
    - o recommends improvement measures to increase environmental performance.

1.3 Scope of audit

The scope of works required to complete the audit comprised the following components:

- a formal risk assessment;
- a gap analysis;
- review of management systems, monitoring and assessments undertaken by MRM during the period from October 2007 to September 2008 via:
    - o statutory compliance assessment;
    - o technical review of data and procedures;
    - o interviews with personnel; and
    - o site inspections;
- review of environmental assessments and monitoring undertaken by DRDPIFR pertaining to the 2008 Operational Period;
- community consultation; and
- provision of an annual report to the Minister for Primary Industry Fisheries and Resources regarding the environmental performance of MRM operations.

The location of the Mine and Bing Bong Port facility is shown in Figure 1.

1.3.1 Focus areas for technical audit review

A number of focus areas were selected by the Independent Monitor to form part of the technical review of environmental monitoring, including:

- hydraulic performance of river diversions;
- success of revegetation and installation of fish habitat within the river diversions;
- surface water and artificial waters;
- seepage monitoring at the Tailings Storage Facility;
- geochemical monitoring of seepage from the Tailings Storage Facility;
- tailings pipeline;
- Overburden Emplacement Facility;
- Bing Bong dredge spoil; and

Source: Google Image 2009

0 50 100 150 200 250

Scale in Kilometres

Source: Google Maps Australia

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Title: **Locality Map**

Location: **McArthur River Mine Northern Territory**

Project: **McArthur River Mine Independent Monitor**			Job No: **209024**
Project Man: **GM**		Scale: **As shown**	**Figure 1**
Drawn By: **LB**		Date: **August 2009**	

- Bing Bong Port facility fugitive dust emissions.

These areas were considered by the Independent Monitor to be areas of the MRM operation that present the most significant potential associated environmental risks. Other lower-risk areas of environmental monitoring not covered within this audit report may be assessed within subsequent audit periods, as it is the intention of the Independent Monitor to hone the audit scope each subsequent Audit period.

1.3.2 Audit timeframe

The timeframe of the audit was focussed on the period from October 2007 to September 2008, which is referred to herein as the '2008 Operational Period'. It must be noted however, that the audit has also taken into account limited information, data and observations that fall outside of the 2008 Operational Period.

1.3.3 Assumptions

The following assumptions have been applied throughout the audit process:

- the Independent Monitor will not collect additional data to that provided by MRM or DRDPIFR;
- the intention of this audit is to identify and discuss issues that the Independent Monitor considers to be of significant environmental risk, or represent a significant inadequacy in environmental performance; and
- issues of lower environmental risk may be assessed and discussed within subsequent audits periods.

1.3.4 Exclusions

The Independent Monitor has not reviewed:

- mine safety;
- social issues arising from the operation of the Mine in the McArthur River Region; or
- information or documentation received after the deadline for receipt of documents, being 22 July 2009.

2 BACKGROUND

2.1 Relevant legislation and guidelines

The following sub-section summarises the relevant legislation, guidelines and standards applicable to the mine, its operations and monitoring requirements.

2.1.1 Commonwealth statutory requirements

The *Environment Protection and Biodiversity Conservation (EPBC) Act* (1999) is the Australian Government's central piece of environmental legislation governing the protection and management of nationally and internationally significant flora, fauna, ecological communities and places of heritage. Under this Act, the MRM project was deemed as having the potential to significantly impact upon threatened and migratory species. As part of the environmental assessment process, MRM's Mining Management Plan (MMP) underwent assessment under the *Environmental Assessment Act,* from which an

Environmental Impact Statement (EIS) and Public Environmental Report (PER) were required to be produced and evaluated. Recommendations and management strategies from within the EIS and PER were incorporated into the MMP, which was then evaluated under the *Mining Management Act.*

Other Commonwealth legislation applicable to the MRM project includes:

- *Aboriginal Land Rights (NT) Act (1976);*
- *Native Title Act (1994);*
- *Aboriginal and Torres Strait Islander Heritage Protection Act (1984); and*
- *National Environment Protection Measure (NEPC, 1999).*

2.1.2 Northern Territory statutory requirements

Northern Territory legislation applicable to the MRM project includes:

- *Public Health Act, 1952;*
- *Aboriginal and Torres Strait Islander Heritage Protection Act, 1984;*
- *Work Health Act, 1986;*
- *Environmental Assessment Act, 1994;*
- *Environmental Offences and Penalties Act, 1996;*
- *Mining Management Act, 2001;*
- *Soil Conservation and Land Utilisation Act, 2001;*
- *Territory Parks and Wildlife Conservation Act, 2001;*
- *Weeds Management Act, 2001;*
- *Dangerous Goods (Roads and Rail Transport) Act, 2004;*
- *Environment Protection (National Pollutant Inventory) Objective Act, 2004;*
- *National Environment Protection Council (Northern Territory) Act, 2004;*
- *Waste Management and Pollution Control Act, 2004;*
- *Water Act, 2004;*
- *Northern Territory Aboriginal Sacred Sites Act, 2006;*
- *Dangerous Goods Act, 2006;*
- *Land, Planning and Mining Tribunal Act, 2006; and*
- *Mining Act, 2007.*

The following regulations and guidelines are also considered relevant to the McArthur River Mine:

- *Mining Management Regulations, 2002;*
- *Dangerous Goods (Roads and Rail Transport) Regulations, 2004;*
- *Waste Management and Pollution Control Regulations, 2004; and*
- *Mining Regulations, 2007.*

2.2 Previous audit – 2006-2007 Operational Period

The previous Audit undertaken in 2008, focussed on the 2006-2007 Operational Period. This was the first Audit report prepared by the Independent Monitor as part of the first year of the five-year contract of engagement.

The 2006/2007 Independent Monitor audit was undertaken in two sections including: a procedural performance review; and a technical review of environmental assessments and monitoring activities. The audit scope comprised:

- an assessment of MRM's procedures and systems to ensure compliance with their statutory commitments and conditions;
- an assessment of DRDPIFR's environmental assessments and audits;
- an assessment of MRM's technical compliance with their conditions and commitments; and
- a review of the environmental performance of the mine based on the environmental monitoring and assessment information available.

2.2.1 Findings from previous audit

McArthur River Mining demonstrated a high level of procedural conformance with statutory commitments and conditions, although one non-conformance was observed in that larval mosquito monitoring breeding sites rectification programs had not been undertaken. The Independent Monitor also noted a number of incomplete conformances; however these did not collectively constitute a non-conformance.

The environmental performance of the MRM operation was deemed difficult to assess through technical review due to considerable data gaps in the monitoring results provided to the Independent Monitor for the 2006/2007 period. The Independent Monitor identified a general inadequacy of interpretation of monitoring results both by MRM, and external consultants.

Consequently, the Independent Monitor identified several monitoring programs that should be improved, and a number of environmental issues that require rectification (corrective action) over the next 3-5 years. These were:

- improved monitoring and improved technical review and interpretation of all water monitoring data around the mine, in particular the assessment of seepage from the Tailings Storage Facility into Surprise Creek;
- improved management and subsequent reduction of fugitive dust emissions at the Bing Bong load-out facility;
- improvement of dust management practices, particularly at the Tailing Storage Facility;
- improved management and rehabilitation of the dredge spoil dump at the Bing Bong facility; and
- adjustments in analytical suites for the surface water and groundwater monitoring programs.

The Independent Monitor Audit of the check monitoring systems and procedures utilised by DRDPIFR revealed that although the sampling techniques used in the field were satisfactory, the procedural documentation for undertaking this work, i.e. sampling manuals, training procedures and checking competency of staff, were not evident or inadequate at the time of the Audit.

The Independent Monitor identified that the check-monitoring can be improved, principally by ensuring that the results of the DRDPIFR monitoring are assessed internally against the results provided by MRM (for the commensurate monitoring event).

2.2.2 MRM rectification program

The Independent Monitor recognises the following programs that MRM has established to rectify or address issues of concern or non-conformances observed. These rectification measures include:

- application of a clay layer covering to approximately 2/3 of Tailings Storage Facility Cell 1, and the application of reclaimed seepage to mitigate tailings dust emissions from the Tailings Storage Facility;
- engagement of an appropriately-qualified hydrogeologist to evaluate the groundwater conditions at the Mine; and
- significant re-roofing of the Bing Bong concentrate storage shed has been undertaken, which will assist in reducing fugitive dust emissions. These works are in addition to further works recommended within this report to reduce fugitive dust emissions and improve the environmental performance of ore concentrate handling.

2.3 MRM shutdown period

On 17 December 2008, the Federal Court ruled that the Federal Government had overlooked environmental concerns in its approval of the MRM open cut expansion. Consequently, MRM were ordered to cease all civil works while the Federal Minister for the Environment Heritage and the Arts re-made his decision as to whether or not to approve the Mine's expansion, having due consideration for all required information.

After a two-month closure period, the Federal Minister, the Honourable Peter Garrett, announced that he had considered the possible environmental impacts associated with the Mine's expansion, and gave Xstrata approval to re-open the Mine upon the condition that MRM prepare a comprehensive monitoring plan. The Independent Monitor will request to review this comprehensive monitoring plan during the next Audit report to be completed in 2010.

Although MRM continued its environmental monitoring throughout the shut-down period, the Independent Monitor has considered the potential material effect of the shut-down period on MRM's environmental performance. As such, this will be considered as part of the next audit report to be completed in 2010 for the subsequent 2008/2009 Operational Period.

3 METHODOLOGY OF AUDIT

3.1 Audit and assessment team

The Audit and assessment process was undertaken by the Independent Monitor team, which comprised the following members:

- Environmental Earth Sciences: Philip Mulvey, Geordie McMillan, and Laura Boland;
- Outback Ecology: Ms Julia Lawson;
- Bewsher Consulting: Mr Don Still; and

- Mining One Pty Ltd: Mr Scott Jenke.

3.2 Documentation reviewed

A list of all documentation provided to the Independent Monitor during this Audit Period is provided within Appendix F, whilst all documentation provided by DRDPIFR is listed within Appendix G.

3.3 Site inspection

Site inspections and meetings associated with the 2008 Operational Period Audit were undertaken as follows:

February 2008 and November 2008	Outback Ecology MRM site inspection.
16 March 2009	Commencement and review meeting between the Independent Monitor, MRM, and DRDPIFR in Darwin.
15-17 June 2009	Site inspection of MRM site and interviews with MRM undertaken by Philip Mulvey, Geordie McMillan, Laura Boland, Scott Jenke, and Don Still.
17 June 2009	Discussions with key Community stakeholders, undertaken by Philip Mulvey, Geordie McMillan, and Laura Boland.
19 June 2009	Interviews with DRDPIFR representatives undertaken by Philip Mulvey, Geordie McMillan and Laura Boland.

3.4 Personnel interviewed

The following personnel were either interviewed by the Independent Monitor and/or were involved with communication throughout the duration of the audit and assessment process:

- Mr Gary Taylor – Manager Health Safety and Environment (HSE), MRM;
- Chris McCleave – Mining Manager;
- Sam Strohmayr – Metallurgy Manager;
- Mr Ettienne Moller – General Manager Xstrata Zinc;
- Mr Steven Pevely – Mine Geologist, MRM;
- Mr Chris Williams – Bing Bong Port Manager, MRM;
- Matthew Bird – Environmental Officer, MRM;
- Ms Eileen McGovern – Team Leader Mining Evaluations, DRDPIFR; and
- Cyrus Edwards – Mining Evaluations, DRDPIFR; and
- Russell Ball – Director Mining Performance, DRDPIFR

3.5 Community consultation

Limited community liaison and consultation was undertaken by the Independent Monitor during the June 2009 site visit on 17 June 2009. Discussions were held with prominent community members, many of whom had met with the Independent Monitor during site visits in 2008. Community members interviewed include:

- Neil Pickett – Shire Services Manager Roper Gulf Shire Council;
- David Harvey – Yanyula Traditional Owner;
- Jackie Green – Northern Land Council;
- Shane Stevens – Northern Land Council;
- Tony Chong – Northern Land Council; and
- Ben Senge and Lincoln Wilson – Northern Territory Parks and Wildlife Service.

4 RISK ASSESSMENT

4.1 Introduction

4.1.1 Purpose

The purpose of the risk assessment was to evaluate environmental risks associated with the monitoring and assessment of the MRM operations. Risks that the Independent Monitor considers to be of greatest environmental significance have been identified within this risk assessment. Other environmental risks will be identified and assessed through subsequent risk assessments undertaken during successive audit periods.

This risk assessment was undertaken to fulfill a requirement set out within the Independent Monitor Scope of Services.

4.1.2 Objective

The objectives of the risk assessment were to:

1. identify the potential environmental risks associated with MRM operations; and
2. evaluate whether environmental monitoring and assessment practices undertaken by MRM are adequate and appropriate to mitigate the risk of potential environmental impacts.

4.1.3 Scope

The scope of the risk assessment is intended to be in line with the scope of the technical audit report in that a focus is placed on issues that the Independent Monitor considers to be of high-level risk. Lower level risk issues will be examined within subsequent audit reports and will be included within updated annual Independent Monitor risk registers.

This risk assessment examines the potential environmental impacts resulting from MRM site operations and Bing Bong Port facilities, including potential environmental impacts associated with:

- river diversions;
- the management of surface water and artificial waters;

- groundwater;
- the Overburden Emplacement Facility;
- Bing Bong dredge spoil;
- Bing Bong Port facility fugitive dust emissions;
- Tailings Storage Facility; and
- the tailings pipeline.

Risks associated with the above assets were evaluated based on the adequacy and effectiveness of MRM's environmental systems, and their capacity to manage these issues via monitoring data and assessment.

Scope of information input
The scope of information input was generally limited to the 2008 Operational Period. However, observations made during the June 2009 site inspection and more recent additional information provided by MRM and DRDPIFR were also used throughout the risk assessment. As such, the scope of the risk assessment comprised all information provided to the Independent Monitor by 22 July 2009.

Temporal and spatial scope of impacts
Both short-term and long term potential environmental impacts were assessed throughout the risk assessment. Similarly, the spatial scope of the risk assessment encompassed potential environmental impacts both within and outside of the mining lease area.

4.1.4 Stakeholders

The following stakeholders were considered to be affected by the potential environmental impacts associated with MRM operations:

- the community of Borroloola;
- flora and fauna;
- future generations;
- McArthur River Mining Pty Ltd; and
- the DRDPIFR.

4.1.5 Assumptions

It was assumed that information provided by MRM and DRDPIFR is an adequate representation of the monitoring and assessment procedures being undertaken.

4.1.6 Exclusions

The risk assessment scope did not include an assessment of:

- lower-risk aspects of the MRM operation (these may be examined within subsequent audit risk assessments);
- data and information provided to the Independent Monitor after 22 July 2009;
- social issues arising from the operation of the Mine in the McArthur River Region; and
- occupational health and safety.

4.2 Methodology

The risk assessment was undertaken in general accordance with the methodology advised within AS/NZS 4360:2004 – *Risk Management*, and HB 436:2004, Companion to AS/NZS 4360:2004 – *Risk Management Guidelines (Standards Australia, 2004a&b).*

Specific elements of the risk assessment methodology are provided in further detail within the following sections.

4.2.1 Risk assessment participants

The risk assessment was undertaken by members of the Independent Monitor team. Independent Monitor team members have the specialist technical and environmental management expertise required to assess the potential risks associated with MRM operations, and evaluate whether monitoring practices are adequate and appropriate. Details of the risk assessment participants are provided below within Table 1.

TABLE 1 RISK ASSESSMENT PARTICIPANTS

Name	Position	Company	Expert input to Risk Assessment	Industry experience (years)
Philip Mulvey	Senior Principal Scientist	Environmental Earth Sciences	Hydrogeology, geochemistry, and environmental management systems (EMS)	28
Geordie McMillan	Senior Scientist	Environmental Earth Sciences	Hydrogeology, geochemistry, EMS	8
Donald Still	Director - Hydrologist	Bewsher Consulting	Surface water and river diversion hydrology	33
Scott Jenke	Senior Geotechnical Engineer	Mining One	Geotechnical engineering	12
Julia Lawson	Group Leader – Approvals,	Outback Ecology	Flora and Fauna	10
Laura Boland	Environmental Scientist	Environmental Earth Sciences	Risk assessment facilitator, EMS	2

Notes:
1. EMS = Environmental management systems.

4.2.2 Risk identification and analysis

Risk identification was undertaken by individuals of the Independent Monitor team within their area of expertise as outlined within Table 1. Independent Monitor team members utilised the following information resources along with their own expert knowledge and experience, to identify potential environmental risks:

- documentation requested by the Independent Monitor and provided by MRM;
- documentation requested by the Independent Monitor and provided by DRDPIFR;
- site inspections undertaken by the Independent Monitor during 2008 and 2009; and

- interviews with MRM and DRDPIFR personnel during site inspections.

Each team member identified and systematically listed environmental risks relating to their area of expertise (e.g. flora and fauna) within the Risk Register (Appendix A). Other aspects considered and recorded within the Risk Register include:

- potential duration of impact (Table 2);
- location of impact (Table 2);
- causes; and
- existing controls, monitoring or assessment undertaken.

TABLE 2 LOCATION AND DURATION OF IMPACT

Code	Location of impact
RI	Regional impact (>2km radius outside mining lease)
OM	Impact outside mine lease area - (<2km radius)
WM	Wide-spread impact within mining lease boundaries
L	Localised area within mining lease boundaries
P	Small point source within mining lease boundary
Code	**Potential duration of impact**
G	Geological long term (>100 years)
L	Long term (30- 100)
M	Medium term (5-30 years)
S	Short term (1-5 years)

4.2.3 Risk evaluation

Risk evaluation was conducted on a residual risk basis with known controls in place. As such, the risk rating derived refers to the risk level based upon the information sources detailed previously in Section 0.

Risk evaluation was undertaken via a qualitative analysis methodology, which was supported by data and other information provided by MRM and DRDPIFR. The risk associated with each potential impact was determined using a matrix of likelihood and potential consequence whereby:

Risk = Consequence + Likelihood

Consequence was determined on the basis of the maximum reasonable consequence the impact may have upon the natural environment if existing monitoring and assessment controls are inadequate or inappropriate. Consequence was considered in light of the both the location and duration of the impact (see Table 2).

The reasonable consequence and likelihood of occurrence was considered for each impact in terms of the scales provided within the risk matrix (Appendix A).

Risk matrix results were correlated with an associated risk rating scale as provided in Appendix A. The results of the risk assessment are recorded within the Risk Register, which is provided Appendix B.

4.3 Outcomes of risk assessment

This section summarises the results of the risk assessment, which are provided within the Risk Register located in Appendix B.

4.3.1 Extreme and high risks

Three “extreme” risk issues were identified through the risk assessment. Two of these risk issues related to the Bing Bond Dredge Spoil, both in terms of dam wall failure and impact of seepage due to the permeability of the wall, which is discussed further within Section 7.1.2. This issue is considered to require immediate attention from MRM and DRDPIFR to mitigate associated environmental impacts. The third extreme risk issue is related to the classification of waste rock as “non-acid forming” (NAF) prior to placement at the overburden emplacement facility (see Section 8.8.5)

Fourteen issues were identified by the Independent Monitor as being “high” risk issues. These are detailed within the full Risk Register provided within Appendix B.

4.3.2 Recommended actions

Risks that are rated as “extreme” or “high” are those that the Independent Monitor considers to warrant an immediate response at a senior management level to eliminate or reduce the risk. As such, it is recommended that MRM and DRDPIFR action the recommendations made by the Independent Monitor within the Risk Register (Appendix B) or provide additional documentary evidence to indicate that risks identified have been mitigated or eliminated appropriately.

4.4 Monitoring and review

The environmental risks associated with MRM operations must be monitored and reviewed periodically to ensure that changing circumstances do not alter risk priorities, and assess the effectiveness of risk management strategies (Standards Australia/NZ, 2006). As such, this risk assessment will be reviewed and updated by the Independent Monitor on an annual basis.

During the next Audit and review period, the Independent Monitor will review the identified risks through assessing the ways in which MRM and DRDPIFR have monitored and managed identified risks since the previous risk assessment. Furthermore, the Independent Monitor will repeat the risk assessment process in order to review the risks and associated management systems, and update the Risk Register (Appendix B).

5 GAP ANALYSIS

5.1 Introduction

5.1.1 Purpose

The purpose of this gap analysis is to identify gaps in environmental monitoring and assessment undertaken for MRM operations that require improvement.

This gap analysis was undertaken as a requirement of the Independent Monitor Scope of Services.

5.1.2 Scope

The gap analysis included a comparison of the environmental performance of MRM against:

- best practice industry standards;
- expert assessment and recommendations; and
- MRM statutory obligations.

Gaps were identified and evaluated through:

- review of monitoring and assessment data and information provided to the Independent Monitor by MRM and DRDPIFR;
- site inspections undertaken by the Independent Monitor team during 2008 and 2009; and
- interviews with MRM and DRDPIFR personnel (see Section 3.4).

5.1.3 Objective

The objectives of the gap analysis are to:

1. identify gaps between the actual environmental performance of MRM, and the environmental performance goals to be achieved; and
2. provide recommendations for improvement measures to remove identified Gaps and enhance environmental performance.

5.1.4 Assumptions

It was assumed that the information provided to the Independent Monitor to date is an adequate representation of the actual environmental performance of MRM operations.

5.1.5 Exclusions

The gap analysis did not consider:

- occupational health and safety;
- monitoring of social issues arising from the operation of the Mine in the McArthur River Region; and
- information provided to the Independent Monitor after the deadline for the receipt of documents.

5.2 Methodology

The gap analysis was undertaken by members of the Independent Monitor team. Each team member separately identified monitoring and assessment gaps within their field of expertise as follows:

- Philip Mulvey and Geordie McMillan: tailings and waste rock geochemistry, groundwater, surface water, air quality, and soil;
- Don Still: river diversion and surface water hydrology;
- Scott Jenke: geotechnical engineering; and
- Julia Lawson: input on flora and fauna, and rehabilitation.

5.2.1 Gap identification and assessment

For the purpose of this gap analysis, a gap is defined as 'a discrepancy between the monitoring program that is taking place, and the monitoring program that should be taking place if MRM's environmental performance is to be maintained at industry best practice standards'. The assessment of a monitoring program includes the design, implementation, and interpretation of the monitoring results.

Independent Monitor team members were asked to identify and assess gaps based on their:

- review of monitoring and assessment data and other information supplied by MRM/DRDPIFR to date;
- expert industry knowledge and experience;
- interviews with MRM/DRDPIFR personnel; and
- observations made during site inspections.

Identified gaps were listed within the Gap Register, a copy of which is provided within Appendix D.

5.2.2 Gap evaluation

To maintain a consistent and systematic methodology between Independent Monitor team consultants, each identified gap was evaluated in accordance with the Gap Analysis Process Flow Chart developed by Environmental Earth Sciences, provided in Appendix C. This flow chart guided the categorisation of identified gaps into one of the gap categories as described in Table 3.

TABLE 3 GAP EVALUATION CATEGORIES

Gap Category	Description
Category 1	Monitoring is not undertaken to mitigate potential associated environmental risk.
Category 2	Monitoring is undertaken, but is not sufficient in design (i.e.: frequency, location, type etc) to identify or quantify potential environmental risk.
Category 3	Monitoring is undertaken and is appropriate in design, however, data/output information is not adequately assessed, interpreted or managed to appropriately mitigate potential environmental risk.

All Gap Categories are considered to have equal weighting; for example, not undertaking appropriate assessment of monitoring data or undertaking appropriate mitigation measures (Category 3 Gap) may have the same adverse impact as not monitoring at all (Category 1 Gap).

5.3 Outcomes of gap analysis

The outcomes of the gap analysis are provided in the Gap Register within Appendix D.

The gap analysis identified a total of 15 Category 1 Gaps. These related primarily to:

- monitoring/reporting of the river diversion works;
- materials testing of the Overburden Emplacement Facility;
- geotechnical issues relating to the Bing Bong spoil pond;
- Bing Bong dredge spoil seepage;
- monitoring of the Tailings Storage Facility and Water Management Dam geotechnical integrity and emergency response;
- mosquito monitoring; and
- warning of extreme flood events.

The Independent Monitor notes that the majority of gaps identified this period were Category 1 Gaps. This is considered to be in line with the audit scope, which places a focus upon significant potential environmental risks. From a compliance view point of view, Category 1 Gaps indicate a monitoring non-compliance that the Independent Monitor views as necessary. The Independent Monitor anticipates that a greater number of Category 2 and 3 Gaps will be identified within subsequent years of Audit as the Independent Monitor scope is further honed. However, key Category 2 and 3 Gaps are related to the assessment of:

- tailings geochemistry;
- riverbank erosion along the river diversions;
- geotechnical monitoring of the Tailings Storage Facility and Water Management Dam;
- regional groundwater;
- fluvial sediment geochemistry;
- flood levels and water flow measurement.

In total, 13 Category 2 and 3 Gaps were recognised by the Independent Monitor group, the details of which are provided within the Gap Register (Appendix D).

5.3.1 Recommended actions

The Independent Monitor recommends that the monitoring or reporting measures suggested by the Independent Monitor within the Gap Register be actioned by MRM, and/or relevant reporting be provided to the Independent Monitor within the next Audit period to demonstrate how identified gaps will be addressed or have been ‘closed’.

5.4 Monitoring and review

This gap analysis will be reviewed by the Independent Monitor on an annual basis and reported within subsequent annual Independent Monitor audit reports. The purpose of annual monitoring and review of gaps will be to:

1. assess whether identified gaps have been eliminated or managed in line with recommendations made by the Independent Monitor; and
2. update the Gap Register.

As such, the Independent Monitor will repeat the gap analysis process for subsequent monitoring years using information provided to the Independent Monitor by MRM and DRDPIFR during the next Audit period.

6 OUTCOMES OF PROCEDURAL AUDIT

6.1 Review of DRDPIFR environmental assessments and audits

The Independent Monitor requested evidence of the following procedures from DRDPIFR:

- DRDPIFR's statutory requirements to undertake the monitoring and evaluation of the environmental performance of the McArthur River Mine, including all environmental assessments and audits undertaken by DRDPIFR;
- forms and procedures that demonstrate the systems, projects and activities undertaken with respect to monitoring the environmental performance of the Mine by the regulator;
- how DRDPIFR interprets the quality and significance of the environmental performance data collected;
- DRDPIFR's report and data-set pertaining to the October 2007 to September 2008 monitoring period; and
- DRDPIFR's current surface water and groundwater sampling and analysis methodology, including but not limited to;
    - sampling method;
    - sampling location and analyte rationale;
    - order of sampling; and
- field quality assurance and control measures, *i.e.* decontamination between sampling points, collection of blind duplicate samples, rinsate blanks, field instrument calibration.

The following documents were subsequently provided to the Independent Monitor as evidence of the above:

- *Procedures Manual – Environmental Monitoring Unit* (DRDPIFR, 2009);
- *Advisory Note: Methodology for the Sampling of Surface Waters* (2009);
- *Advisory Note: Methodology for the Sampling of Ground Waters* (2009);
- *Water Management Plan (WMP) – Advisory note for sites identified by the Department* (2008);

- various correspondences between MRM and DRDPIFR relating to approvals, and assessment/ evaluation of environmental monitoring activities (full list is provided in Appendix G);
- two examples of project management plan excerpts (not specifically relating to MRM operations); and
- examples of programs and data for surface water and groundwater check monitoring (see Appendix G).

A full list of documentation provided by DRDPIFR for review is provided in Appendix G.

The Independent Monitor considers the above procedural documents to provide evidence that DRDPIFR undertakes its own check monitoring of MRM's monitoring performance.

6.1.1 Review of DRDPIFR assessments and monitoring activities

The Independent Monitor understands that regular audits of MRM are undertaken by DRDPIFR, which include audits of the environmental performance of the Mine as well as compliance against Mining Management Plan (MMP) commitments.

No formal audit or assessment reports were provided to the Independent Monitor within the designated timeframe for receipt of documents. Although one Mining Management Plan Compliance Assessment report was submitted to the Independent Monitor, this report was submitted after the cut off-date for receipt of documents for this audit period. As such, the Independent Monitor will review this report as part of a more rigorous audit of DRDPIFR's management procedures within the next audit period during 2010.

6.2 Procedural audit of McArthur River Mining

Table 4 summarises the procedural audit undertaken for MRM Operations. In accordance with the audit scope (Section 1.3), the procedural audit of MRM focussed upon key procedures that the Independent Monitor considered to be associated with areas of significant potential environmental risk. A detailed procedural audit was undertaken in 2008 as part of the first year of the Independent Monitor program.

Note that conformance only implies that the activity or commitment was performed, and not that the Independent Monitor agrees or disagrees with the technical interpretation of the activity.

The audit of the procedures and systems on the selected commitments and conditions provided in Table 4 have demonstrated a high level of conformance by providing evidence of the works undertaken, and commitments to undertake further work or continual improvement; however three non-conformances for the 2007-2008 Operational Period were observed. These included:

- no evidence of work being undertaken regarding accelerated salt leaching, stabilising revegetated landforms, and undertaking annual vegetation surveys on the Bing Bong dredge spoil ponds;
- in-place testing of clay liner beneath the Overburden Emplacement Facility has not been undertaken; and
- mosquito monitoring and abatement programs were not undertaken.

The Independent Monitor has, however, considered the following information in relation to these non-conformances:

- Section 4.20.6 of the Annual Environment Report (AER) (MRM, 2009a) provides guidance on earlier vegetation monitoring works undertaken on the dredge ponds, and also states that “unfortunately due to proposed future dredging activities, this monitoring program (sic.) has been postponed until further notice”. The Independent Monitor has also previously viewed research proposals by Charles Darwin University to undertake rehabilitation trials which, similar to the aforementioned vegetation monitoring, has been postponed until further notice;
- McArthur River Mining has notified the Independent Monitor that procedural documents will be altered to require in-place testing of the Overburden Emplacement Facility clay liner as part of future extension works; and
- it is noted that the Independent Monitor has viewed documentation provided by MRM including procedures on sampling and reporting, consultation with Environmental Health Authorities, along with the commitment to establish mosquito monitoring systems in the near future, and develop abatement and management strategies, if required.

Observations and recommendations for improving the procedures and documentation for the following commitments are provided as follows:

- appropriate measurement for abstraction of water from the McArthur River;
- classification of waste rock from the pit for placement in the Overburden Emplacement Facility;
- establishment and maintenance of a perimeter fence to keep stock and feral animals out;
- integration of the McArthur River Mine Operational Simulation (OPSIM) modeling recommendations for site and Tailings Storage Facility water management;
- regular checklist monitoring of the Bing Bong Port facility, in particular the dredge spoil ponds; and
- use of wire mesh instead of clean waste rock in sealing the underground portal.

TABLE 4 PROCEDURAL AUDIT OF MRM MONITORING

Procedural evidence requested	Documentation provided (Document name)	Evidence of competency, training and continual improvement	Conformance/ observations
MRM will maintain and update a weed management plan annually	Weed Management Plan 2006 V2 JNC Weed Management Plan 2008 Vers 2 FINAL Feb Weed Management Plan 2009	MRM Environmental Officer (EO) responsible for site weed management. Job description for MEM EO viewed May 2008. Employees, contractors and visitors are advised in inductions of weed species identification, management & importance of washdown procedures. Induction material for the environmental section of the Civil/General site induction procedure viewed (May 2008).	Conformance.
MRM is and will continue to collect native seed for revegetation of rechannel areas, and will undertake regular monitoring of revegetation and provide feedback (to stakeholders)	090415_MRM_Memorandum edition 10_final ADM-CRE-PRO-6020-0015 External Communication procedure I001 MCARI6257_Newsletter_Jan08 MCARI6409_Newsletter_final MCARI6564_AugustNewsletter_FINAL Memorandum - edition 6 Native Seed Invoices MRM Vegetation Rehab report April 08	In May 2008, the Independent Monitor viewed the job description for the Environmental Superintendent and EO, who are responsible. Seed collection by Top End Seeds (accredited by Greening Australia).	Conformance.
Abstraction of water from the McArthur River was undertaken at or below 20% of river flow	Southern Cross Extraction Totals	May 2008, Independent Monitor viewed job description for Senior Environmental Advisor (responsible). Position currently vacant. SEA verbally trains EO in downloading data. Procedure slated for modification (May 2008).	Conformance but procedure should be documented.
Materials used in the civil construction works were non-acid forming (NAF) and were mapped and classified by an experienced geologist	PRO 071030 Rock Sampling – JSB EDIT_MIN_TEC_SOP_1000_0007_Ore Spotting and Grade Control Results of NAFPAF Testing – Barney Creek and McArthur River Diversions REG 071121 Barney Rock Sampling Data – JSB REG 071223 McArthur Rock Sampling Data – JSB JSA 071030 Rock Sampling – JSB	May 2008 – ultimate responsibility is that of Senior Mine Geologist, with verification works by Mine Surveyor and Mine Geologist(s), both JDs viewed.	Conformance, although discussions w/ Stephen Pevely (MRM) indicate waste rock classification procedures need updating.

Procedural evidence requested	Documentation provided (Document name)	Evidence of competency, training and continual improvement	Conformance/ observations
Monitoring of erosion and sediment control measures was undertaken on an event basis depending on rainfall (& within 25 hours of rainfall of 25 mm or greater)	GEN-ENV-MAN-6040-0001 Environmental Monitoring Manual 2007 GEN-ENV-MAN-6040-0001 Environmental Monitoring Manual 2009	Mining Manger's and Environmental Superintendent's responsibility, who trains the EO to inspect stockpiles, note changes.	Conformance.
MRM have relocated aquatic species trapped in the original river channel	GEN-ENV-PRO-6040-0017 Fauna Management Procedure I001 Rev 0.doc Photos of fish removal from Barney Creek during construction Photos of fish removal from old McArthur River during construction of new channel.	May 2008 - HSE Manager responsible.	Conformance.
MRM is and will continue to construct a 17 km perimeter fence around the open cut project to prevent movement of stock into rehabilitation works	Perimeter Fence Invoices- Remote Mining and Maintenance Pty Ltd All fencing Services NT Quote MEET 081002 October Meeting Minutes re: cattle mustering Map of fencing location	May 2008 - HSE Manager and Mining Manager.	Conformance, but fence requires rapid repair to stop ingress of cattle and donkeys following the wet season. However, it is acknowledged that fence damage due to flooding will occur annually.
MRM has taken geo-referenced aerial photographs (or after major flood events)	2007 aerial photograph of Mine site and Bing Bong 2008 aerial photograph of Mine site and Bing Bong	May 2008 – HSE Manager overall responsible, photos also used in mine planning.	Conformance (however, no evidence of interpretation at Bing Bong)
MRM has identified and remediated potential barriers to fish movement during construction works	Photographs of pipes that were installed where the levee crossed the McArthur River to allow fish movement	May 2008 – HSE Manager responsible, rectification works undertaken by Mining (Civil) Manager	Conformance.
MRM has applied any suitable recommendations arising from the engineering study regarding spill mitigation from the tailings pipeline	14103250 File Note 020108 File Note: Tails Line Leak detection and Wear Detection. File Note Tails Diameter and pump selection File Note: Tails Line Size & Pumps File Note Tails Line Design Parameters 090602 File Note: Tails Line Design Parameters File Note TAILS PUMPS 120707 File Note: Tailings Pumps Selection MRM Tailings Line Design 071120 MRM Tailings Line: Discussion on Expansion Considerations	May 2008 – Mill Production Superintendent's responsibility.	Conformance.

Procedural evidence requested	Documentation provided (Document name)	Evidence of competency, training and continual improvement	Conformance/ observations
Tailings dam pipeline thickness, wear patterns and scale build-up was assessed annually	Tailings Pipeline Thickness Test Result Tailings pipeline thickness test work order and completion	May 2008 – Mill Production Superintendent's responsibility.	Conformance.
Outcomes of the OPSIM assessment were used to upgrade TSF water management strategies and/or TSF water management infrastructure to provide a tool to predict the site water balance and assist in maintaining the current low probability of overflow	No documentation provided. (Final OPSIM report is yet to be finalised).	May 2008 – HSE Superintendent's responsibility (position vacant, falls to HSE Manager).	Observation – draft OPSIM report received but documentation on implementation of recommendations required.
Structural surveillance of the TSF and associated infrastructure was conducted regularly	2008_04 April Monthly Report- Tailings Storage Facility Monthly Operating Report DAM Safety Review Report Allan Watson and Associates 2008- McArthur River Mining Pty Ltd - McArthur River mine Tailings Storage Facility Dam Safety Review Report (2008) McArthur River Tailings Dam and Surrounds 1 Jan 08 - McArthur River Mining Corrective Action report Tailings Dam and Surrounds (Template) and Inspection checklist sheet. McArthur River Tailings Dam and Surrounds 2 March 08 - McArthur River Mining Planned area inspection checklist Tailings Dam and Surrounds McArthur River Tailings Dam and Surrounds 3 May 08 - McArthur River Mining Planned area inspection checklist Tailings Dam and Surrounds McArthur River Tailings Dam and Surrounds Inspection April 09 - McArthur River Mining Planned area inspection checklist Tailings Dam and Surrounds	May 2008 – Mill Production Superintendent's responsibility.	Conformance.
Tailings geochemistry has been monitored	Three examples of geochemical sample collection and processing forms and lab transcripts.	May 2008 – HSE Manager / Superintendent responsible, sampling by EO/ technicians. Sampled according to MRM Technical Manual for Environmental Monitoring.	Conformance. (Monitoring undertaken, but no evidence of assessment and mitigation).
Piezometric levels within the TSF embankment, water levels in the decanting pond and the embankment condition were monitored	Water management Dam and TSF spillway level readings - List of Inspection times for monitoring.	May 2008 – Mill Production Manager and Environmental Technician's responsibility.	Conformance. (No piezometers in TSF Cell 1 outer embankment).

Procedural evidence requested	Documentation provided (Document name)	Evidence of competency, training and continual improvement	Conformance/ observations
TSF is fenced off from cattle and fencing was inspected regularly	Remote Mining and Maintenance Pty Ltd invoice for fence repair	May 2008 – HSE Manager responsibility.	Conformance.
Rehabilitation trials were conducted on portions of Cell 1 of the TSF	GEN-ENV-PLN-6040-0005 Rechannel Rehabilitation Plan I001 Re Xstrata_Zinc_MRM_Closure_Plan_20080325 final - Preliminary Mine Closure Plan Xstrata - McArthur River Mining Phase 1 & 2 Report – Draft - Development of a Conceptual Cover System Design for Closure of the Tailings Storage Facility Cell #1 TSF Cell 1 Rehabilitation Stage 1 proposal form - Investment proposal form Daily update of water usage, clay placed and HSE info from CDE - Earth works summary – TSF Rehabilitation of the Tailings Dam contract - Earth works contract for TSF Capping Tax invoice progress claim from CDE to undergo rehab - CDE Capital Invoice	May 2008 – Mill Production Manager responsible for spigot, recovery bores, geopolymer and electricity usage. HSE Manager responsible for OPSIM, water and environmental monitoring. MRM procedures to be updated accordingly.	Conformance.
NAF/PAF overburden has been placed in clay cells in the Overburden Emplacement Facility	MRM North Overburden Emplacement Facility PAF cells May 2009_GT - PowerPoint presentation - PAF Cell Construction	May 2008 – ultimate responsibility is that of the Senior Mine Geologist, with verification works by Mine Surveyor and Mine Geologist(s).	1)Non-conformance regarding geotechnical testing of clay liner in place; 2)Conformance. Observation: annual report (MMP or AER) should specify volumes and waste classification of waste rock generated and placed in Overburden Emplacement Facility cells. 3) Actual procedures appear to be better than written procedures. Written procedures meed updating to reflect procedures being undertaken.

Procedural evidence requested	Documentation provided (Document name)	Evidence of competency, training and continual improvement	Conformance/ observations
Geochemical testing of waste materials was conducted as part of an on-going program	EDIT_MIN_TEC_SOP_1000_0007_Ore Spotting and Grade Control NOEF - 3D Computer-generated figure NOEF Geology Samples (2) Excel sheet- Sample collection log RE points of sampling etc - Email regarding NOEF Map Waste rock sampling quote from ALS - ALS Analysis quote Memorandum: The background on waste classification at McArthur River Mine	May 2008 – ultimate responsibility is that of the Senior Mine Geologist, with verification works by Mine Surveyor and Mine Geologist(s).	Conformance. Observation: although discussions w/ Stephen Pevely (MRM) indicate waste rock classification procedures need updating (see comment above).
MRM obtained any necessary approvals from the NT government prior to undertaking any significant activities	LETT 071011 MMP Submission letter signed.gt - Submission of McArthur River Mine 2007-2008 Mining Management Plan - Letter to DPIFM Changes on concentrate storage and approval 0811 - The storage of concentrate at McArthur River Mine (letter to DPIFM), and Re: McArthur River Mine Project - Sampling schedule/analysis temporary storage of concentrate (response letter from DPIFM to MRM). Water abstraction for McArthur River Mine (Letter to DPIFM from MRM) and McArthur River Project - Water abstraction amendment to the McArthur Mine River Mining Management Plan (Response letter from DPIRM to MRM) Amendments to the McArthur River Mine Mining Management Plan (Letter to DPIFM) and Re: McArthur River Project- Amendments to the McArthur Mine River Mining Management Plan (response letter from DPIFM to MRM). Submission as per Commonwealth Approvals for McArthur River Open Cut Project (Letter to Hon Peter Garrett from MRM). (No title) Response letter from the Australian Government Department of the Environment, Water, Heritage and the Arts to MRM.	May 2008 – all modifications to MMP and plans undertaken by HSE Manager.	Conformance
MRM provided six-monthly updates on implementation of environmental monitoring programs, in addition to annual reports	Letter request from DRDPIFR on monitoring results on a quarterly basis - RE: Quarterly submission of water quality data.	May 2008 – HSE Manager responsibility.	Conformance.

Procedural evidence requested	Documentation provided (Document name)	Evidence of competency, training and continual improvement	Conformance/ observations
MRM has conducted an annual review of the site-wide risk register	2009 MRM Risk Register - HSEC HAZARDS IDENTIFICATION AND RISK ASSESSMENT- Excel Spreadsheet. GEN-HSE-PRO-6040-0004 Risk Management Procedure I001 Rev 0.doc	May 2008 – HSE Manager responsible.	Conformance
Reporting of environmental incidents has been conducted	Three examples of environmental incidents provided. GEN-HSE-PRO-6040-0002 INCIDENT REPORTING PROCEDURE I002 Rev	May 2008 – HSE Manager responsible. External notification is made by the HSE Manager on a discretionary basis. Actions are assigned, put in 'SiteSafe' system, and procedures are updated depending on investigation outcomes.	Conformance.
Bing Bong port facility has been inspected and maintained on a continuous basis as part of a preventative maintenance program	Action list for inspection of dust suppression system – *Aburri HSEC inspection May 08* *Aburri HSEC inspection March 08* *Aburri HSEC inspection Oct 08* *Bing Bong HSEC Inspection Feb 08* *Bing Bong HSEC Inspection May 08* *Bing Bong HSEC Inspection Oct 08* *Bing Bong HSEC Inspection Dec 08* *Workplace safety observation examples*	May 2008 – Mill Production Manager's responsibility, with dredge pond inspections meant to be done by Bing Bong staff.	Conformance: Observation: No specific HSE inspection checklist for dredge spoil ponds.
MRM have reviewed the performance of the dredge spoil bund wall, undertaken by experienced personnel at Bing Bong	*Email from site project engineer on work completed on the spoil area prior to wet season*	May 2008 – joint responsibility of Bing Bong Manager and HSE Manager.	Conformance: Observation: procedures for checking the condition of the dredge ponds need to be developed.
Accelerated salt leaching, stable revegetated landform and annual vegetation surveys will be conducted on Bing Bong dredge spoil dump	No documentation provided	May 2008 – HSE Manager responsible.	Non-conformance
Conveyor and vehicle declines were sealed with clean waste rock	*2x pictures of portal with metal barricade* *2x pictures of conveyor outlet with metal barricade*	May 2008 – Mining Manager and HSE Manager responsible.	Conformance. Observation: mesh used instead, should be updated in MMP.
Mosquito monitoring procedures (Non-conformance from last Audit)	No documentation was received for the 2007-2008 monitoring period. The Independent Monitor notes receipt of information indicating planning to start mosquito monitoring in 2009.	HSE Manager responsible.	Non-conformance

7 ISSUES REQUIRING FURTHER INVESTIGATION AND REPORTING

7.1 Issues requiring urgent investigation and reporting

The Independent Monitor Assessment Conditions (IMACs) Section 6.4 provides the mechanism for the Independent Monitor to report issues that it considers require urgent investigation and reporting. In such an instance, the Independent Monitor must advise the Operator (MRM) and DRDPIFR of the issue(s) as soon as practicable, and may include recommendations as to appropriate action to be taken.

Following the Independent Monitor's June 2009 site inspection and review of documents provided by McArthur River Mining (MRM), the Independent Monitor considered two separate issues to warrant reporting and investigation under IMACs Section 6.4; these were:

1. seepage from Cell 1 of the Tailings Storage Facility into Surprise Creek; and
2. salt discharge through dam walls at the Bing Bong Dredge Spoil Ponds.

7.1.1 Issue 1 - Seepage from Tailings Storage Facility Cell 1 to Surprise Creek

Cell 1 at the Tailings Storage Facility is unlined and in close proximity to Surprise Creek. The presence of alluvium (sands, sandy-clays and silts) and also potential 'paleochannels' (conducive discrete zones of sands and gravels) have resulted in leachate migration from the Tailings Storage Facility to the creek, which was known to have occurred within 2 years of commencement of tailings deposition (c. 1997).

As part of the approval of the open cut operation, a 'geopolymer' barrier system was put in place in 2005 to prevent migration to the creek, which was also designed to augment the existing recovery bores located at approximate 50 m intervals that were installed in the preceding year.

The Draft Environmental Impact Statement (URS, 2005a) observes that "*analysis of tailings samples taken from Cell No 1 (in 2004) indicate that the tailings are currently pH neutral to slightly alkaline…… the most recent geochemical tests on near-surface tailings samples at the TSF indicate that some near-surface materials are likely to be PAF if exposed to oxidising conditions for some length of time.*"

This document also states that reliance on net acid generation (NAG) tests may be inappropriate and that net acid production potential (NAPP) results appear to be increasing with time.

The Draft Environmental Impact Statement (URS, 2005a) notes that cadmium and lead are sparingly soluble (i.e. have low mobility through pore water) and should remain in the solid phase. It also stated that it expected that the leachate water within the Tailings Storage Facility will be at neutral pH and the concentrations of the metals in the leachate will remain within drinking water guidelines for stock watering use.

Although it was acknowledged that the tailings may acidify over time, it was not considered likely in the short-term and any acid generation would not mobilise heavy metals from the tailings.

Furthermore, the geopolymer barrier wall installed in 2005/6 was considered successful in stopping salt-laden leachate reaching Surprise Creek. This was considered an additional safeguard if the tailings did produce acid in the future.

During an inspection of Cell 1 of the Tailings Storage Facility on 15 June 2009, the Independent Monitor noted that water from the recovery bores was being pumped back to the top of Cell 1 and applied across the surface to minimise dust emissions. This recovered water was seen to form a "moat" around the outer surface of Cell 1, which eventually drained into Cell 2.

Free water was standing in the moat had exceptional clarity with iron sulfate salts, both of which indicate a pH of between 3.6 and 3.8. Field testing of this water later in the week by MRM confirmed that the pH of this water was between 3.4 and 3.8.

Following a review of tailings geochemistry results for the 2007-2008 period, it is apparent that more acid is being generated than predicted by the NAG test, but less acid than predicted by NAPP. When the tailings started to produce acid, the amount and rate of acid generation and the impact on the geopolymer barrier was obviously, and continues to be, unknown (this has been identified as a Category 3 Gap within the Gap Register – see Appendix D). Thus, predicting the impact on the environment and designing the necessary mitigation measures cannot be readily achieved at this time.

A preliminary conceptual geochemical model of seepage migration from the Tailings Storage Facility is presented in Figure 2, which provides the likely processes occurring.

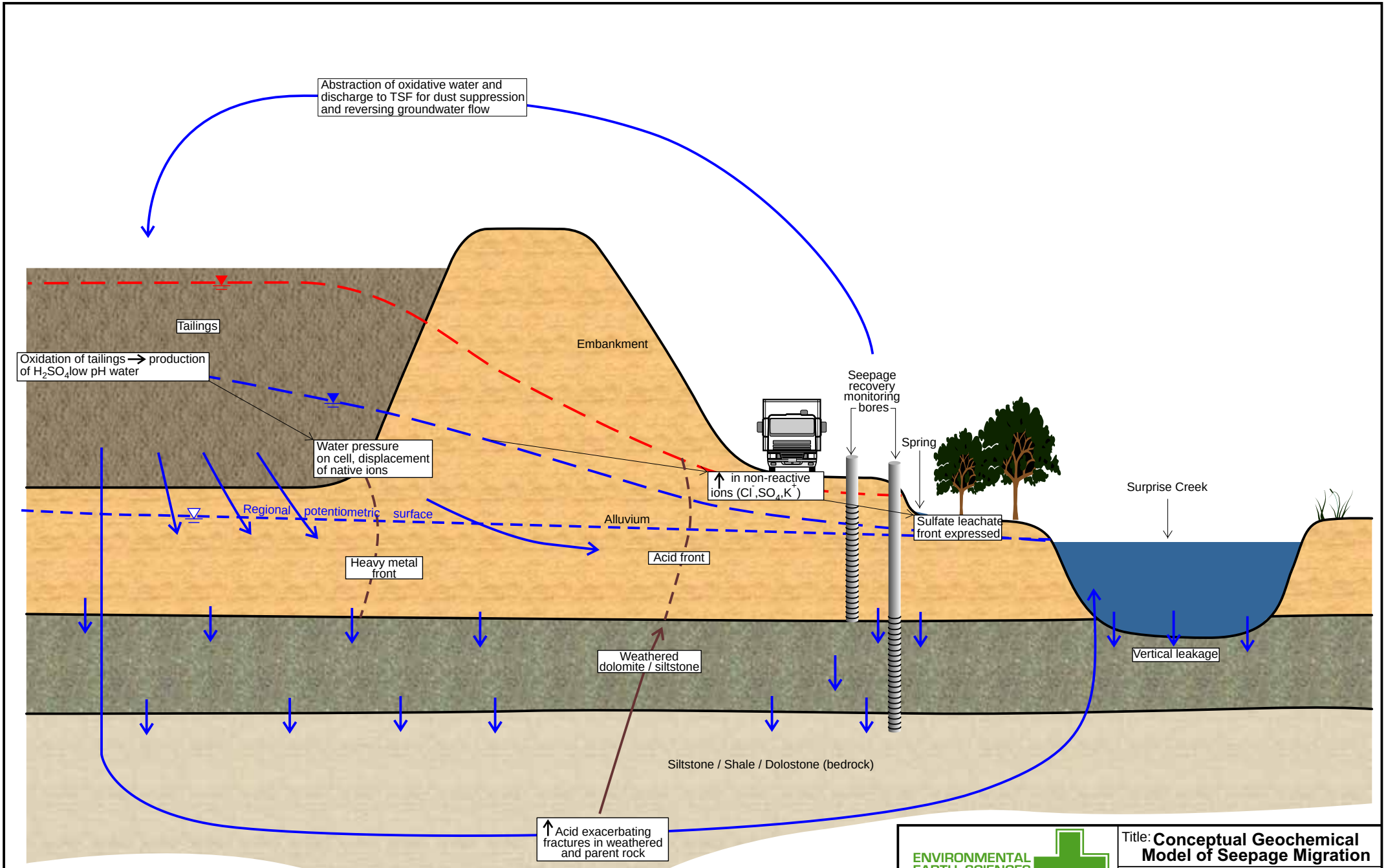
The Independent Monitor provided detailed recommendations for further investigation into this matter within a letter *McArthur River Mine Independent Monitor – notification of investigation under Section 6.4 of the IMAC* to General Manager McArthur River Mining (cc: DRDPIFR) dated 6 July 2009 (Environmental Earth Sciences, 2009).

7.1.2 Issue 2 – salt discharge through dam walls at Bing Bong Dredge Spoil Ponds

The Dredge Spoil Ponds are located to the east of the Bing Bong Load-out Facility, and are also outside the Mining Lease. They were constructed in the mid 1990s by scraping the existing shelly-sand to form bunds. In some instances, this was done outside the pond and other instances inside the pond. Thus the pond walls are constructed of permeable shelly-sand that is subject to tunnelling erosion.

The site is located on vegetated former estuarine mud flats and as such, is consequently very flat. Local vegetation is salt tolerant (up to TDS of about 15 000 mg/L) and the Independent Monitor identified tea tree, pig face and *atriplex* species, amongst many others being present. Melaleuca species grow in areas with fresher water. The road to the public boat ramp runs past and partially over the bund of the ponds, providing a clear view of the ponds to the general public.

Dredging reportedly occurred again in 2006, and another dredging event is scheduled for 2009. Because of the lack of relief in the landscape, the preferential pathway for saline drainage is through the bund walls and onto the coastal flats rather than to the designed discharge drain. The salt levels in the impacted areas are substantially greater than local flora and fauna can adapte to. Thus, a substantial area of salt scalds and salt-degraded land exists to the west and to the south of the dredge spoil ponds. Furthermore, it appears that the ponds drained to the south-east and south-west since the initial dredging in the mid-1990s.



ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Conceptual Geochemical Model of Seepage Migration**

Location: **McArthur River Mine Northern Territory**

Project: **McArthur River Mine Independent Monitor**		Job No: **209024**
Project Man: **GM**	Scale: **Not to Scale**	**Figure 2**
Drawn By: **LB**	Date: **August 2009**	

The Independent Monitor considers that the area impacted is substantial and could be more extensive than initial appearances indicate, as dieback to the south-west appears to be widespread. Aerial photographs of the Bing Bong area taken in 1995, 2005, and c.2009 are presented in Figures 3, 4, 5, and 7.

The Independent Monitor provided a number of recommendations within the letter to MRM dated 6 July 2009 (Environmental Earth Sciences, 2009), including:

- provision of additional aerial photographs;
- survey of land levels to delineate preferential water flow pathways;
- analysis of surface waters;
- analysis of dredged material for total oxidisable sulfur;
- a detailed historical study into the usage of the Bing Bong dredging program and disposal of the dredge material;
- outer shallow wide drains and resurfacing of the pond walls is required before the next dredging period; and
- an upgraded monitoring program during dredge spoil emplacement and during the wet season is required.

Following the Independent Monitor's June 2009 site inspection, the Independent Monitor received correspondence from MRM outlining MRM's understanding of some of the more significant issues raised during the site inspection. Within this correspondence, MRM advised that they had undertaken soil sampling at locations around the dredge spoil ponds to analyse seepage impacts. The locations of these sampling points are presented in Figure 6.

7.2 Issues raised by the Community

The Independent Monitor consulted with Borroloola Community members (listed in Section 3.5) in relation to any concerns they had regarding environmental impacts of MRM. Two issues of concern previously identified by Community members during the 2008 Independent Monitor visit were discussed further with the community. These issues were:

- the reported depletion of "ink berries" (referred to as "Jibradidi" in the local language, and which the Independent Monitor believes to be *Carissa lanceolata)* in the vicinity of the tailings dam; and
- the observed depletion of the Agile Wallaby population (*Macropus agilis*) and Short-eared Rock Wallaby (*Petrogale brachyotis*) in the area of the Bing Bong Port.

The Independent Monitor consulted with personnel at the Northern Territory Parks and Wildlife Service in Borroloola regarding the above issues. Through discussions it was established that due to climatic factors, the "ink berry" (also known as "concker berry") had a poor season, in which very few bushes bore fruit on a regional scale. The Independent Monitor is confident that the recent lack of "ink berries" is due to climatic reasons, and not due to MRM operations.

Source: Northern Territory Department of Infrastructure and Planning

0 2500

Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Bing Bong Facility Regional Aerial Photograph - 1995**

Location: **McArthur River Mine Northern Territory**

Project: **McArthur River Mine Independent Monitor**		Job No: **209024**	
Project Man: **GM**	Scale: **As shown**	**Figure 3**	
Drawn By: **LB**	Date: **August 2009**		

Source: Northern Territory Department of Infrastructure and Planning

0 100 200 300 400 500

Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Bing Bong Facility Aerial Photograph - 1995 (enlargement)**

Location: **McArthur River Mine Northern Territory**

Project: **McArthur River Mine Independent Monitor**		Job No: **209024**	
Project Man: **GM**	Scale: **As shown**	**Figure 4**	
Drawn By: **LB**	Date: **August 2009**		

Source: Google Earth 2009

0 1000

Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Bing Bong Facility Aerial Photograph - 2005**			
Location: **McArthur River Mine Northern Territory**			
Project: **McArthur River Mine Independent Monitor**		Job No: **209024**	
Project Man: **GM**	Scale: **As shown**	**Figure 5**	
Drawn By: **LB**	Date: **August 2009**		

Source: Figure provided to Independent Monitor by MRM

0 100 200 300 400 500

Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Soil Salinity Sampling Locations by MRM 18/06/09**

Location: **McArthur River Mine Northern Territory**

Project: **McArthur River Mine Independent Monitor**		Job No: **209024**	
Project Man: **GM**	Scale: **As shown**	**Figure 6**	
Drawn By: **LB**	Date: **August 2009**		

Source: NT Department of Infrastructure and Planning C.2009

0 400 800 1200 1600 2000

Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title:	**Bing Bong Facility Aerial Photograph c.2009**
Location:	**McArthur River Mine Northern Territory**
Project: **McArthur River Mine Independent Monitor**	Job No: **209024**
Project Man: **GM**	Scale: **As shown**
Drawn By: **LB**	Date: **August 2009**

Figure 7

The abundance of the abovementioned wallaby populations was also discussed with the NT Parks and Wildlife Service, during which it was established that the Short-eared Rock Wallaby prefers thick shrubs and the absence of humans, whilst the Agile Wallaby numbers are known to fluctuate gently between wet seasons. The effects of MRM operations on these Wallaby populations at Bing Bong Port will be further evaluated by the Independent Monitor in subsequent audits.

Another issue of concern raised by one Community member related to alleged inadequacy of clean-up of concentrate spills cause by truck accidents en route to the Bing Bong Port facility. This issue was raised with MRM during the June 2009 Independent Monitor site inspection. McArthur River Mining subsequently provided the Independent Monitor with relevant photographs and evidence of incident reporting and clean-up of four spill incidents occurring in September 2004, March 2005, January 2001, and November 2000.

The Independent Monitor is satisfied that clean up of these incidents has been handled in an appropriate manner so as to limit significant environmental harm, if the relevant procedures provided to the Independent Monitor have been followed. However, the Independent Monitor notes that validation soil sampling results as per MRM *General Spill Response* Procedure (MRM, 2007j) have not been sighted, with the exception of the 2001 spill. Even still, these 2001 results provided are unclear regarding the origin or method of collection.

The Independent Monitor notes that over-excavation (if possible) and validation sampling of the affected spill area is not explicitly mentioned within the MRM *Major Concentrate Spill – Trucking procedure (MRM, 2007k).* Independent Monitor advises that it would be beneficial to include such measures in this procedure to eliminate associated environmental risks.

8 OUTCOMES OF TECHNICAL AUDIT

8.1 Introduction

In accordance with the audit scope (see Section 1.3.1), a number of focus areas were selected by the Independent Monitor to form part of the technical review of environmental monitoring. These focus areas were those that the Independent Monitor considered to be of greatest environmental significance.

The Independent Monitor considers that reviewing the environmental performance of MRM operations requires an evaluation of the technical data, and interpretation thereof to fully assess the environmental performance of Mine operations. For example, whilst a mine operator may have excellent systems and procedures in place, if the method of data collection, analysis and technical interpretation is unsuitable or requires improvement, then this undermines the evaluation of the environmental performance.

The Independent Monitor's technical review of monitoring data generally pertaining to the 2008 Operational Period is presented for each focus area within the following sections.

8.2 Review of surface water and artificial water monitoring

The Independent Monitor acknowledges and commends MRM for the improvements made in presenting and evaluating the surface water and artificial water monitoring in the AER (MRM,

2009a). The locations of surface water and artificial water monitoring are provided in Figures 8 and 9 respectively.
The Independent Monitor notes that contingencies and adjustments in sampling have been provided in Section 4.4.5 of the AER, including:

- an exceedence of trigger values or site criteria is recognised where the concentration of a contaminant of concern is greater than 10% of the background value (where site specific hardness modified trigger values do not apply);
- internal trigger values will be developed and applied to natural surface waters within the mine lease;
- field filtering of samples will no longer be conducted; and
- sites will only be monitored when water at the location is flowing, with 'cease to flow' conditions' recorded appropriately (as recommended by DRDPIFR).

The Independent Monitor concurs with the cessation of field filtering of surface water samples, if samples can be delivered to the laboratory within 24-48 hours of collection; however due the remote location of the Mine, this may not always be possible. Furthermore, if in-field filtering is not undertaken, the sample may not be representative of actual conditions, or may not be comparable to DRDPIFR check-monitoring. As such DRDPIFR has advised the Independent Monitor of their preference for filtering in-field, and appropriate preservation.

Although the Independent Monitor understands the basis for undertaking sampling only when natural surface waterways are flowing, stagnant waterways and waterholes are still a beneficial use for ecosystems that require protection, regardless of flow conditions. As such, monitoring and sampling at all designated locations should continue regardless of flow, as long as flow conditions are adequately recorded. This is particularly important during 'first flush' flow events in the early stages of the wet season, where the sudden onset of fresh oxidative water stirs up settled biota and organic matter, often resulting in fish kills. These fish kills are generally a natural occurrence but the continuation of monitoring throughout the year will allow the Mine to evaluate whether these incidents occurred because of a natural 'first flush' event, or impacts from mine operations.

The Independent Monitor is in general agreement with the discussion of natural surface and artificial water monitoring results provided in the AER (MRM, 2009a), which is significantly improved on the 2006-2007 report provided during the previous audit. However some of our criticisms from the 2006-2007 monitoring period report still remain, which are presented as follows:

- laboratory transcripts, chain of custody forms and quality assurance/control interpretation of results are not provided in the AER or supporting documentation. Whilst the Independent Monitor acknowledges that due to the large volume of monitoring data generated, this information could perhaps be provided as a DVD attachment to the report; and
- there are gaps in the chemicals of concern analysed. Monitoring commitments provided in Table 4.18 of the AER have either not been adhered to or not discussed/tabulated, with the non-analysis of total suspended solids, chloride, hardness (as calcium carbonate), cations (calcium, potassium, sodium, magnesium), nitrogen, phosphorus, and chlorophyll.

Source: MRM, 2009a

0 2000
Scale in Metres

Legend
- Surface water

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Surface Water and Fluvial Sediment Sampling Locations**

Location: **McArthur River Mine Northern Territory**

Project: **McArthur River Mine Independent Monitor**		Job No: **209024**	
Project Man: **GM**	Scale: **As shown**	**Figure 8**	
Drawn By: **LB**	Date: **August 2009**		

Source: MRM, 2009a

0 300 600 900 1200 1500

Scale in Metres

Legend

- Artificial water

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Artificial Surface Water Sampling Locations**

Location: **McArthur River Mine Northern Territory**

Project: **McArthur River Mine Independent Monitor**		Job No: **209024**	
Project Man: **GM**	Scale: **As shown**	**Figure 9**	
Drawn By: **LB**	Date: **August 2009**		

Surface and artificial water recommendations
The Independent Monitor provides the following recommendations for improving the environmental performance of the Mine with respect to the monitoring and management of surface and artificial waters:

- interpretation and discussion of quality assurance and quality control (QA/QC) procedures should be provided in the AER (MRM, 2009a). This can be as an appendix and also incorporates QA/QC discussions for other monitoring including groundwater, soil and sediments; and
- where there are gaps in the data-set due to sampling locations being dry, inaccessible, unsuitable to sample or if no sampling was undertaken, explanations for these gaps should be provided as part of the AER (MRM, 2009a). This can be either in the text of the document or tabulated as an appendix, and is an essential component of ensuring compliance with the stated monitoring frequency and analysis commitments.

Statistical analysis of surface water and groundwater monitoring data is considered by the Independent Monitor to be an insensitive tool to detect changes in water quality; particularly with respect to detecting changes within the background range. A change from host rock dependent water quality to early detection of mine seepage influence requires and understanding of solute transport and attenuation. Such an event is best detected by a technical determination of groundwater chemistry against a seepage model. Statistical evaluation will only detect the plume once the main contamination front has passed.

8.3 Review of groundwater monitoring

The Independent Monitor acknowledges that the content and quality of the AER for the 2007-2008 monitoring period, which actually incorporates 2005-2008 data, has improved substantially since the 2006-2007 monitoring period, and we acknowledge the efforts made by MRM to engage a suitably qualified hydrogeologist to evaluate the groundwater conditions at the Mine and Tailings Storage Facility since the expansion. We understand that the works, which commenced in May 2009, will involve most groundwater-related aspects, however it is critical that the modelling and further investigation works around the Tailings Storage Facility (as per Section 7.1.1 notification) be conducted as soon as possible.

Groundwater sampling locations around the Mine site and the Tailings Storage Facility are provided in Figures 10 and 11.

The Independent Monitor notes that in correspondence between MRM and DRDPIFR in 2009, a request has been made from MRM to DRDPIFR for reductions in the frequency of monitoring groundwater from bi-monthly to quarterly, and then from quarterly to bi-annually. The Independent Monitor disagrees with this change, and recommends that at a minimum, monthly monitoring should be undertaken, particularly around the Tailings Storage Facility until a detailed hydrogeological evaluation is made and conceptual model is completed by a qualified hydrogeologist. The outcome of such a review each year will be to consider, amongst other things, the frequency of monitoring. A reduction in monitoring frequency would be considered in light of such a review.

It is noted that there has been an improvement in the consistency of both monitoring frequency and analysis of groundwaters from the 2006-2007 to the 2007-2008 monitoring period. However, data gaps remain in both the sampling frequency and analytical regime, which either has not been reported in the AER (MRM, 2009a) and databases provided by MRM to the Independent Monitor, or the sampling and analysis was not undertaken.

Source: MRM 2009a; MRM 2008a

0 200 400 600 800 1000

Scale in Metres

Legend

Groundwater

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Mine Site Groundwater Sampling Locations**

Location: **McArthur River Mine Northern Territory**

Project: **McArthur River Mine Independent Monitor**

Job No: **209024**

Project Man: **GM**

Scale: **As shown**

Drawn By: **LB**

Date: **August 2009**

Figure 10

Source: MRM 2009a; MRM 2008a

Legend
- Groundwater
- Seepage recovery bores

0 200 400 600 800 1000
Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Tailings Storage Facility Groundwater Sampling and Seepage Recovery Bore Locations**

Location: **McArthur River Mine Northern Territory**

Project: **McArthur River Mine Independent Monitor**		Job No: **209024**
Project Man: **GM**	Scale: **As shown**	**Figure 11**
Drawn By: **LB**	Date: **August 2009**	

Regardless, explanations for these data gaps should be provided in the AER, which may be due to inaccessibility, dry sampling locations, etc, which was acknowledged to some degree by MRM in Section 4.6.5 of the AER (MRM, 2009a).

As stated in Section 10.4.5 of the MMP (MRM, 2008a), the objectives of MRM's groundwater monitoring program are to:

- monitor the impacts of groundwater abstraction;
- assess the effectiveness of Tailings Storage Facility seepage control systems;
- assess potential impact of the establishment of the north Overburden Emplacement Facility; and
- determine the extent of any contaminants in shallow aquifers.

The Independent Monitor acknowledges the discussion in Section 4.6.5 of the AER (MRM, 2009a) that the hydrogeochemistry of the background alluvial sediments has an approximate signature of (sodium-magnesium -calcium)-(sulphate-chloride) with salinity approximating 1000 mg/L total dissolved salts; however, this is based on previous studies and does not examine the spatial and temporal trends in groundwater chemistry and quality.

Despite gaps in the monitoring data-set for bores GW6 and GW7 (Figure 11), groundwater chemistry at these locations indicates marginally increasing salinity and a (magnesium/calcium-sodium)-(chloride-sulfate) signature with increasing sulphate, which may be due to localised mounding of water within Cell 2 of the Tailings Storage Facility and minor seepage.

The Independent Monitor concurs with the discussion in Section 4.6.5 of the AER (MRM, 2009a) that:

- groundwater quality at bores adjacent to Surprise Creek has stabilised, although the overall temporal trend indicates increasing concentrations of sulphate and other tailings leachate indicators, in addition to the continued salt impact on vegetation and the Surprise Creek bank; and
- decommissioning of Cell 1 is likely to reduce seepage to Surprise Creek, although this is likely to be slower if reclaimed seepage water is used for dust control on Cell 1.

However, the decommissioning of Cell 1 will only reduce the rate of seepage migration to Surprise Creek if it is undertaken in conjunction with further hydrogeological investigations of mitigation measures. These may include: further drilling along the main salt breakthrough pathway to determine the degree of fracturing in the underlying rock (dolomite/shale); accelerated leaching of the tailings; installation of a leachate collection trench/cut-off wall; and infilling of the geopolymer barrier. A preliminary conceptual geochemical and hydrogeological model of potential and actual seepage migration from Cell 1 of the Tailings Storage Facility to Surprise Creek is presented in Figure 2.

During the June 2009 field inspection, the Independent Monitor observed examples of completed field observation records, measurements and chain of custody forms for the dispatch and specification of analytical requirements of collected samples.

As previously discussed, MRM are commended for engaging a recognised hydrogeological consultancy in evaluating the groundwater conditions at the Mine and Tailings Storage Facility. We are cognisant of this undertaking however, some criticisms from the 2006-2007 monitoring period report still remain as follows:

- laboratory transcripts, chain of custody forms and quality assurance/control interpretation of results are not provided in the AER (MRM, 2009a) or supporting documentation. This is particularly important in validating the precision, accuracy and reproducibility of results;
- there are gaps in both the frequency of sampling recorded and chemicals of concern analysed. Monitoring commitments provided in Table 4.18 of the AER (MRM, 2009a) have not been adhered to at many locations, with the non-analysis of total suspended solids, chloride and hardness (likely to be measured as calcium carbonate), and inconsistent monitoring of many locations;
- no groundwater potentiometric contours for the mine site, Tailings Storage Facility and dewatering/ borefield locations have been developed. These are essential in determining changes in groundwater levels of time, inferred flow direction and also to assess the impact of mine dewatering, borefield operations and the potential for seepage migration from the Tailings Storage Facility to Surprise Creek. At a minimum, potentiometric contours should be developed for the Tailings Storage Facility and mine site bi-annually; and
- there are no records of monitoring undertaken on the bore-field and "T" nomenclature bores to evaluate the effects of dewatering on the Djirrinmini waterhole and the regional aquifers.

Groundwater recommendations

The Independent Monitor provides the following recommendations for improving the environmental performance of the Mine with respect to the monitoring and management of groundwater:

- monitoring and abstraction bores that have been decommissioned, destroyed or not considered to suitable for on-going monitoring should be decommissioned in accordance with *Minimum Construction Requirements for Water Bores in Australia* (Land and Water Biodiversity Committee, 2003) to mitigate potential contamination of aquifers;
- updated figures should be provided in each year's MMP and AER that show the current and used monitoring and abstraction bores, including seepage recovery bores at the Tailings Storage Facility;
- critical evaluation of the performance of the seepage recovery system at the Tailings Storage Facility and the numerical model developed for the dewatering of the regional aquifer as part of the Mine expansion should be provided annually. The Independent Monitor has inspected exported data from the Tailings Storage Facility recovery bores and an example of the Recovery Bore Monitoring Sheet;
- where there are gaps in the data-set due to sampling locations being dry, inaccessible, unsuitable to sample or if no sampling was undertaken, explanations for these gaps should be provided as part of the AER. This can be either in the text of the document or tabulated as an appendix, as this is an essential component of ensuring compliance with the stated monitoring frequency and analysis commitments; and
- bi-monthly or, at a minimum quarterly, groundwater monitoring should include analysis for pH and TDS (for comparison against field measurements), cations (sodium, calcium, magnesium, potassium, ammonium), anions (chloride, bicarbonate (may be as calcium carbonate), sulfate, nitrate) and dissolved heavy metals (aluminium, arsenic, iron, manganese, lead, nickel, zinc).

The Independent Monitor acknowledges the efforts made by MRM in improving their groundwater monitoring program and interpretation of data. We understand that from 2009, the delivery of this information will be in the form of Water Management Reports to be submitted to DRDPIFR.

The August 2008 groundwater monitoring data-set provided by MRM (laboratory spreadsheet transcripts EL11650, EL11675, EL11689 and EL11731), which was provided as part of the procedural review, indicates that substantial improvements have been made in ensuring that sampling compliance is met

8.4 Review of dust, soil and sediment monitoring

8.4.1 Dust monitoring

Mine site

A site inspection was undertaken by the Independent Monitor team during June 2009. The following observations were made during the site inspection of the Tailings Storage Facility:

- fugitive dust emissions from Tailings Storage Facility Cell 1 have been markedly reduced since the last Independent Monitor inspection. This has been managed through capping approximately 2/3 of the cell with clay, and also pumping reclaimed tailings seepage back on to the top of Cell 1 to dampen the remaining un-capped surface area. Only minor dust generations was observed during the site inspection;
- the reclaimed tailings seepage was observed to pond within areas across the surface of Cell 1. These ponds were observed to contain jarosite and goethite formations and salt crystallisation (see Plate 1 - Appendix E);
- the Independent Monitor noted gully erosion at the edge of the perimeter road at the north east foot of Tailings Storage Facility Cell 1. MRM advised the Independent Monitor that this erosion had been reported as a health safety and environment (HSE) incident, and was about to undergo rectification. The Independent Monitor observed a stream of tailings seepage draining from the area of gully erosion into Surprise Creek. Salt crystallisation was observed along the seepage stream line to Surprise Creek; and
- salt crystallisation was observed along the edges of Surprise creek at the area where the Creek is closest to the Tailings Storage Facility Wall (see Plate 2 - Appendix E).

The dust and soil monitoring locations for the mine site area are provided within Figure 12.

The 2009 site inspection, which occurred during the dry season, showed that rehabilitation trials on parts of Cell 1 of the Tailings Storage Facility have been effective in reducing dust generation during dry periods, particularly in comparison with observations made during the 2008 field inspection.

The Independent Monitor notes that there are no baseline pre-mining dust levels for the mine site, Tailings Storage Facility or Bing Bong load-out facility for comparison against current levels. This renders the development of site and contaminant-specific guidelines for dust as problematic; however temporal and spatial trends can still be evaluated, which also account for the effects of the wet and dry seasons.

The Independent Monitor is in general agreement with the discussion of dust monitoring results in Section 4.10 of the AER (MRM, 2009a), however temporal trends are evident at several locations based on Figure 4.30 with the AER. This figure plots the total solid dust

values at sampling points D8, D21, D22, D23, D24 and D28 from November 2005 to June 2008.

Although these trends are not linear in nature, they do show a rapid decrease in dust levels in early 2008 following sharp increases as a result of rainfall variations. This rapid decrease may be due to improvements in dust management at the Run of Mine Pad and Pacrim, and the Tailings Storage Facility. The Independent Monitor will continue to review this as excessive dust generation, which may pose an adverse risk to human health (short to medium term) and the environment (medium to longer term accumulation).

In June 2009, the Independent Monitor observed evident dust fallout on soil and vegetation on a tributary of Barney Creek near the toe of the ROM pad (See Plate 3 - Appendix E). This is likely to be in the vicinity of dust monitoring gauge D23, to which the Independent Monitor will continue to closely review the efficacy of dust management strategies in this area.

Bing Bong Port facility
Site inspection observations made by the Independent Monitor during the June 2009 inspection included the following:

- dust suppression strategies were in place at the time of site inspection including:
    - lateral spray hoses placed along the asphalt surrounding the concentrated storage shed;
    - spray hoses and wheel sprays are installed along the truck dumping bridge and platform within the storage shed; and
    - the Arburri barge is equipped with sprays for dust suppression during load out.
- both entries to the storage shed are kept open to limit the build-up of sulfate gas within the shed; However, this increases the chance of fugitive dust emissions; and
- minor soil contamination was observed below the wharf transfer chute, where the asphalt has eroded away, exposing the soil to hydrocarbon contamination and fugitive dust emissions (see Plate 4 - Appendix E)

The dust monitoring program at the Bing Bong load-out facility, which comprises gauges BB1 to BB1, does not indicate an overall increase in total solid values over time, however, as discussed by MRM in Section 4.20.4 of the AER, concentrations of lead and zinc increased during 2007-2008 compared to previous monitoring years. Surprisingly, this is not supported by increase heavy metals in beach sediments during the same period (see Section 8.5.2)

The dust and soil monitoring locations for the Bing Bong Port Facility area are provided within Figure 13.

The Independent Monitor recommends a detailed fugitive dust emission audit for the Bing Bong Port facility, as was also recommended in the previous Independent Monitor report. The ore geochemical signature considered to be evident in marine sediments, based on the interpretation of Munksgaard and Parry (2007) *Report on metal concentrations and Pb-isotope ratios in beach sediments east and west of the Bing Bong Load-Out Facility* prepared for MRM, is most probably due to fugitive dust emissions.

Dust management improvement strategies at Bing Bong may include evaluations of the configuration of vehicle entrance and exit points, reviewing exhaust and ventilation systems, and repairing shed walls and roofs that have degraded over time due to salt from northerly sea breezes. Substantial re-roofing has occurred in the last 12 months and hopefully this will assist in reducing fugitive dust emissions.

Source: MRM 2009a

Legend

- Dust and Soil

0 2000

Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Mine Area Dust and Soil Monitoring Locations**		
Location: **McArthur River Mine Northern Territory**		
Project: **McArthur River Mine Independent Monitor**		Job No: **209024**
Project Man: **GM**	Scale: **As shown**	**Figure 12**
Drawn By: **LB**	Date: **August 2009**	

Source: MRM 2009a

0 50 100 150 200 250

Scale in Metres

Legend

Dust and Soil

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Bing Bong Dust and Soil Monitoring Locations**

Location: **McArthur River Mine Northern Territory**

Project: **McArthur River Mine Independent Monitor**

Job No: **209024**

Project Man: **GM**

Scale: **As shown**

Drawn By: **LB**

Date: **August 2009**

Figure 13

Based on the June 2009 inspection by the Independent Monitor, generation of dust from the haulage and storage of concentrate at Bing Bong is considered to be a major long-term issue for the environmental performance of MRM and the occupational health and safety (OHS) requirements of site workers.

The Independent Monitor acknowledges that MRM have substantially improved their reporting of the dust monitoring activities undertaken at the Mine, Tailings Storage Facility and Bing Bong in the 2007-2008 period, compared to the 2006-2007 monitoring period.

8.4.2 Soil monitoring

Soil monitoring at both the Mine site and Bing Bong is undertaken at the dust monitoring gauges to evaluate potential adverse impacts from dust fallout on soil quality. Soil monitoring locations are provided within Figures 12 and 13. Similarly to the dust monitoring described in Section 8.4.1, the presentation and interpretation of the data collected for the 2007-2008 monitoring period has substantially improved compared to the 2006-2007 monitoring period.

The Independent Monitor concurs with the supposition by MRM that surface soil data shows an increasing spatial trend in concentrations of lead and zinc towards the mine site. The highest concentrations are found near the Run of Mine Pad and Pacrim yard, with the spatial trend predominantly due to prevailing south-easterly winds.

Surface soil levels at the Bing Bong load-out facility have either stabilised or reduced over time, with the highest concentrations of lead and zinc at location BBS02 (Figure 13), which is consistent with the elevated dust levels at this location (west/ north-west of the loading shed).

The Independent Monitor understands that substantial dust mitigation measures employed in 2008 by MRM will be further evaluated in 2009 to determine if these have been successful in reducing total dust fallout levels and in turn, reduce the increasing temporal trend of lead and zinc concentrations in surface soils at the mine site.

The Independent Monitor is cognisant of the substantial improvement in the monitoring and reporting of the soil monitoring works, however some of our criticisms from the 2006-2007 monitoring period report still remain, which include:

- laboratory transcripts, chain of custody forms and quality assurance/control interpretation of results are not provided in the AER or supporting documentation. This is particularly important in validating the precision, accuracy and reproducibility of results; and
- no data has been provided or the results interpreted for the analysis of soil pH, electrolytic conductivity, particle size distribution, major cations (sodium, calcium, magnesium, potassium) and selected heavy metals (arsenic, iron, manganese), all of which are monitoring commitments provided in Table 4.18 of the AER (MRM, 2009a).

Soil monitoring recommendations

The Independent Monitor provides the following recommendations for improving the environmental performance of the Mine with respect to the monitoring and management of soil at the mine site and Bing Bong load-out facility:

- ensure that all monitoring commitments, including sampling locations, frequency and analysis, are adhered to and reported in the 2008-2009 AER; and
- using concentrations of arsenic, cadmium, cromium, copper, iron, manganese and zinc in background surface soils, develop site-specific ecological investigation levels for

soils at the mine site and Bing Bong. This can be undertaken in accordance with Hamon *et al.,* (2004) - *Geochemical indices allow estimation of heavy metal background concentrations in soils*. Global Biogeochemical Cycles, Vol 18, GB1014, which is a recognised method for developing background concentrations.

Prevention of soil contamination
The independent Monitor noted that the bitumen surface adjoining the surface water sump/drain at the foot of the load out conveyor at Bing Bong had broken, up partially exposing the soil underneath. Dust and spills from the loading facility are washed to this drain (see Plate 4 - AppendixE). Therefore, the soil exposed at this area is becoming contaminated with ore concentrate and hydrocarbons. It is recommended that the contaminated surficial soil is removed, and the pavement reinstated in this area so as to exclude access to soil.

8.4.3 Fluvial sediment monitoring

The Independent Monitor notes that although the monitoring reporting and interpretation of fluvial sediments in 2007-2008 has improved compared to the 2006-2007 period, several exceedences of adopted investigation criteria of lead and zinc occurred consistently, whilst elevated concentrations of lead and zinc remain at downstream Barney Creek locations FS03 and FS05. Fluvial sediment sampling locations are included within Figure 8.

The Independent Monitor commends MRM for stating that due to the increasing temporal trends in concentrations of lead and zinc at fluvial sediment sampling locations FS01 to FS05, “MRM will undertake pre and post 2008-09 wet season monitoring… samples from which will be prepared using a dilute acid soluble digest (1 M hydrochloric acid) to determine the bioavailable fraction. Data will be reviewed on receipt and appropriate mitigation measures undertaken.”

The recognition of these temporal trends is a welcome inclusion in the 2005-2008 AER however, the Independent Monitor strongly recommends that where additional works are being undertaken to address breaches in adopted site criteria, that the mitigation and/or contingency measures alluded to across all segments of the environment at MRM, should be stated explicitly in the AER.

Similar to the Independent Monitor’s determination of the 2006-2007 monitoring period, the elevated concentrations of lead and zinc in fluvial sediments at downstream locations in Barney and Surprise Creeks through to the delta are considered to be derived from dust fallout from the Tailings Storage Facility and are also likely to be from the Run of Mine Pad at the mine site.

These elevated concentrations may not immediately be evident in downstream monitoring locations in the McArthur River, and the Independent Monitor concurs with the statement by MRM in Section 4.9 of the AER (MRM, 2009a) that “immediate action will be taken by MRM to identify sedimentation source(s) and mitigation measures undertaken prior to the 2008-09 wet season.” The outcomes of these investigations and on-going monitoring will be closely examined as part of the Independent Monitor’s review of the 2008-2009 monitoring period.

Although there has been improvement in the procedures and reporting of the fluvial sediment monitoring works, some criticisms from the 2006-2007 monitoring period report still remain, which are presented below:

- laboratory transcripts, chain of custody forms and quality assurance/control interpretation of results are not provided in the AER or supporting documentation;

- inconsistent monitoring, particularly at locations FS09 to FS21, is evident. The statement that "only one data set was available for FS09 to FS21 which are not discussed further in this report" is insufficient and does not provide any explanation for the non-compliance in monitoring at these locations; and
- no data has been provided regarding the results interpreted for the analysis of sediment pH, electrolytic conductivity, particle size distribution, major cations (sodium, calcium, magnesium, potassium) and arsenic, all of which are monitoring commitments provided in Table 4.18 of the AER (MRM, 2009a).

Fluvial sediment monitoring recommendations
The Independent Monitor provides the following recommendations for improving the environmental performance of the Mine with respect to the monitoring and management of fluvial sediment at the mine site:

- ensure that all monitoring commitments, including sampling locations, frequency and analysis, are adhered and reported on in the 2008-2009 AER; and
- in the 2008-2009 monitoring period MMP and AER, and the new Water Management Report requirement (if necessary), highlight the sedimentation investigation and mitigation measures undertaken.

8.5 Review of marine monitoring

8.5.1 Seawater quality monitoring

Monitoring of seawater at the eight designated locations occurred on a monthly basis during the 2007-2008 monitoring period, which is in accordance with the commitments in the AER (MRM, 2009a). It is noted that no presentation or interpretation of monitoring results for total dissolved salts, total suspended solids, turbidity, arsenic and iron is provided in the AER, which are monitoring commitments. Bing Bong seawater and marine sediment sampling locations are provided in Figure 14.

The Independent Monitor notes that concentrations of most chemicals of concern, primarily lead and zinc, have decreased in 2007-2008 compared to previous monitoring years. Concentrations of lead and zinc at sampling points MSW07 and MSW08 continue to be elevated within the Swing Basin area closest to the loading area, although the concentrations have reduced since previous monitoring years.

Based on the results presented in the AER for 2005-2008 (MRM, 2009a), the Independent Monitor provides the following recommendations for improving the environmental performance of the Mine with respect to the monitoring of seawater at the Bing Bong load-out facility:

- ensure that laboratory transcripts, chain of custody forms and quality assurance/control interpretation of results are provided in future AERs or supporting documentation; and
- ensure that all monitoring commitments, including sampling locations, frequency and analysis, are adhered and reported on in the 2008-2009 AER.

8.5.2 Marine sediment monitoring – swing basin and shipping channel

Marine sediments within the swing basin and shipping channel at the Bing Bong load-out facility are monitored on a bi-annual basis, the analytes for which include:

- particle size distribution;

- major cations (sodium, calcium, magnesium, potassium);
- heavy metals: arsenic, cadmium, copper, iron, lead, zinc, (total and 63 µm fractions); and
- lead-isotope ratios.

Although the presentation and interpretation of this monitoring has improved compared to the previous audit, there is no presentation or interpretation of monitoring results for particle size distribution, major cations, arsenic and iron, and lead-isotope ratios provided in the AER (MRM, 2009a), which are monitoring commitments.

The Independent Monitor concurs with the statement by MRM in Section 4.20.2 of the AER (MRM, 2009a) that there is likely to be spatial variability in sediment heavy metal concentrations due to bioturbation, and that the only exceedences of the low ANZECC (Australian and New Zealand Conservation Council) interim sediment quality guidelines (ISQG-low) for lead and zinc were incurred at transects within the swing basin.

However, statistical monitoring data presented in Table 4.15 of the AER (MRM, 2009a) shows either stable to increasing concentrations of heavy metals in swing basin and shipping channel sediments, particularly closer to the load-out facility. These increases over time indicate that fugitive dust emissions and concentrate handling are likely to be contributing to the increase in concentrations. The Independent Monitor recognises that a further shipping channel and swing basin dredge program was slated for late 2008, which would likely reduce these concentrations, however the continuing and increasing source of heavy metals to the sediment is of concern and will be closely reviewed by the Independent Monitor to ensure that these do not become an adverse risk to beneficial uses. The build-up of heavy metal concentrations in sediments since November 2006 (the last time the channel was dredged) indicates that fugitive dust emissions and ore concentrate handling needs to be improved.

The results of the lead-isotopes studies, which were not conducted during the 2007-2008 monitoring period, would have been highly beneficial in determining the correlation of elevated lead and zinc concentrations in sediment with the geochemical signature of the ore concentrate. The Independent Monitor recommends that the studies listed below undertaken by Charles Darwin University (Munksgaard and Parry, 2007a, b &c), be continued on an annual basis (at a minimum) to ensure that fugitive dust emission and ore concentrate handling procedures are improved. These studies include:

- metal concentrations and lead isotope ratios in beach sediments east and west of the Bing Bong load-out facility (see Figure 15 for sampling transect locations); and
- metal concentrations and lead isotope ratios in seafloor sediments from the trans-shipment area.

Based on the results presented in the AER (MRM, 2009a), the Independent Monitor provides the following recommendations for improving the environmental performance of the McArthur River Mine with respect to the monitoring of marine sediments in the swing basin and shipping channel at the Bing Bong load-out facility:

- ensure that laboratory transcripts, chain of custody forms and quality assurance/control interpretation of results are provided in future AERs or supporting documentation; and
- ensure that all monitoring commitments, including sampling locations, frequency and analysis, are adhered and reported on in the 2008-2009 AER.

Source: MRM 2009a

ENVIRONMENTAL EARTH SCIENCES THE KNOW AND THE HOW	Title: **Bing Bong Seawater and Marine Sediment Sample Locations**	
	Location: **McArthur River Mine Northern Territory**	
Project: **McArthur River Mine Independent Monitor**		Job No: **209024**
Project Man: **GM**	Scale: **As shown**	**Figure 14**
Drawn By: **LB**	Date: **August 2009**	

Source: Google Earth 2009 and MRM 2009a

0 250
Scale in Metres

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title:	**Bing Bong Beach Sediment Transects**
Location:	**McArthur River Mine Northern Territory**
Project: **McArthur River Mine Independent Monitor**	Job No: **209024**
Project Man: **GM**	Scale: **As shown**
Drawn By: **LB**	Date: **August 2009**
	Figure 15

8.5.3 Dredge monitoring

The Independent Monitor notes and commends MRM for providing a proposed monitoring program for the next dredging event, which was originally scheduled for late 2008 but has now been postponed. This program included monitoring of in-situ water quality, discharge water quality, sediment, aquatic, flora and rehabilitation.

Further to the notification of investigation described in Section 7.1 of this report, the Independent Monitor recommends that this proposed monitoring program be revised pending the outcomes of the investigation works recommended by the Independent Monitor regarding the Bing Bong dredge spoil ponds.

8.5.4 McArthur River Delta and Sir Edward Pellew Islands Monitoring

Monitoring in the McArthur River Delta region was undertaken in 2008 for heavy metals in sediments, oysters, and quality of the water column. This was the second monitoring event for this region. Heavy metal concentrations in water were found to be consistent with regional background levels (although some levels had increased at some sampling locations), but primarily, all showed results of increased suspended sediment. Once again no impact of mine-sourced lead was discernable in sediments and in oysters. Unfortunately, lead isotope analysis was not undertaken on suspended lead in the water column, as sampling had previously shown a clear correlation of ore-body lead in the water column. It was hoped that dust reduction measures at the tailings dam may have reduced or eliminated this chemical signature in the delta area, however, as the lead-isotope analysis was not performed on suspended sediments, this cannot be ascertained. The Independent Monitor recommends that lead isotope analysis of suspended sediments be included in the analysis suit for the next monitoring event.

8.6 Review of flora and fauna monitoring

Overall, the Independent Monitor is satisfied that MRM has complied with, and implemented is environmental commitments detailed in the MMP in relation to flora and fauna monitoring and rehabilitation. It should be noted, however, that the 2005-2008 amended AER finalised in January 2009 (MRM, 2009a), is a significant improvement upon the previous version issued in April 2008; this is particularly evident in the presentation and analysis of water quality monitoring data. The AER is improved and presents more detail, and analysis of results, with the exception of the description of rehabilitation works in *Section 6* of the AER (MRM, 2009a).

8.6.1 Mine site flora monitoring (terrestrial)

The Independent Monitor can confirm that vegetation monitoring is being/ has been undertaken in accordance with the MRM MMP (MRM, 2008a) and *Rechannel Rehabilitation Plan* (MRM, 2009c). However, the AER (MRM, 2009a) does not assess the effectiveness of the rehabilitation of the Barney Creek and McArthur River channel diversions and the Bing Bong dredge spoil area. Additionally, there is no discussion on planned rehabilitation for the 2009 reporting period. The seeding success rates do not appear to be adequately discussed, particularly regarding how seeding success will impact further rehabilitation efforts and maintenance activities. The consultant's report for the assessment of analogue riparian vegetation sites (Bellairs, 2008) states that a comparative analysis would be reported on following the assessment of the Barney Creek vegetation later in 2008. The Independent Monitor advises that a summary of these findings would have improved the quality of reporting in the AER prior to its finalisation in January 2009.

The AER (MRM, 2009a) states that the rehabilitation of Barney Creek is complete however, the Independent Monitor recommends that targeted tubestock and canegrass planting occur in the Barney Creek diversion in 2009. It is recommended that additional rehabilitation efforts are required to achieve a stable riparian ecosystem.

During the Independent Monitor's December 2008 site inspection, it was noted that the MRM plant nursery contained an abundance of stock to be planted prior to the arrival of the 2008/2009 wet season. At the time, MRM significantly downsized its workforce which the Independent Monitor expects may have hindered the completion of the rehabilitation program, and result in loss of viable tubestock in the nursery. It is however, acknowledged that the shut-down period (see Section 2.3) did not allow MRM to undertake civil works, including tree planting and rehabilitation of the channel. The Independent Monitor recommends that MRM ensure adequate resources are available in 2009 to maintain the rehabilitation program and nursery stock.

The Independent Monitor considers that regular inspections of the fence around the rechannel works may not have been undertaken in accordance with the *Rechannel Rehabilitation Plan* (MRM, 2009c), as fencing around the mine site had not been maintained adequately at the time of site inspection, which was approximately four months after the end of the wet season. There was also evidence of donkeys and cattle grazing within rehabilitated areas during the June 2009 inspection. The Independent Monitor acknowledges that fences will inevitably be damaged by flood waters each season, however these should be rapidly repaired. McArthur River Mining advised that, at the time this report, fencing had been completed along with cattle mustering.

The Independent Monitor observed infestations of weeds, namely Nogoora Burr (*Xanthium occidentale),* along the river diversion channels during both the December 2008 and June 2009 Independent Monitor inspections. Whilst MRM advised the Independent Monitor that considerable efforts had gone into weed control including spraying and manual removal along Barney Creek; such a program is yet to be implemented for the McArthur River. The Independent Monitor considers that the presence of the observed weeds indicates that additional efforts are required to minimise weeds in the rechannel works. As such, MRM have advised the Independent Monitor in a letter dated 17 June 2009, that additional resources will be injected into the ongoing weed control program prior to the 2009/2010 wet season, and acknowledged that this work must be continuous during both the initial rehabilitation stage and throughout the life of the Mine.

8.6.2 Mine site fauna monitoring

Fish monitoring

The Independent Monitor confirms that fish monitoring has been undertaken bi-annually since May 2006 in compliance with the MRM MMP (MRM, 2008a). It is noted, however that no information is provided in the AER (MRM, 2009a) regarding heavy metal analysis of fish tissue in accordance with MMP (MRM, 2008a) commitments. The Independent Monitor will request to view this information (if it exists) during the next audit period in 2010.

Section 10.4.9.4 of the MMP (MRM, 2008a: 299) states that "…from a public and ecological perspective, it is important that Barramundi are shown to use the re-channelled sections to reach upstream parts of the river"; However tagging survey results for Barramundi *(Lates calcarifer)* are not discussed in the AER (MRM, 2009a). Nine Barramundi specimens were captured in the McArthur River during sampling in November 2008 (Indo-Pacific Environmental, 2009). Additionally, during this survey, it was observed that Barramundi taken from Djirrinmini and Eight Mile waterholes appeared to be underweight, had pale or blotched skin colour and/or early stages of fin rot, however, there is no discussion regarding

the potential impacts of the McArthur River diversion on Barramundi, even though it is highlighted in the MMP (MRM, 2008a) as an important species to be monitored.

The Independent Monitor notes that the report on the fish fauna of the McArthur River (Indo-Pacific Environmental, 2009) states that "although numerous snags in the form of boulders and large logs secured by chain were introduced into the diversion, the density of snags appears to be less than in adjacent parts of the channel". As such the Independent Monitor recommends that the density of snags is increased in the river diversion. While an increase in snag density provides additional fish habitat and aids in the migration of fishes by providing areas of reduced flow, woody debris is also effective in capturing riverine sediments which will aid in the stablisation of the banks, as well as encouraging the establishment of vegetation (Indo-Pacific Environmental, 2009).

Bird monitoring
The Independent Monitor is of the opinion that bird monitoring is being undertaken in accordance with the MRM MMP (MRM, 2008a) since commencement in the late dry season of 2006. Bird monitoring indicates that areas that have been planted with tubestocks have shown a greater similarity in birds present in adjacent open woodland, indicating better recovery (EMS, 2008).

It was recommended in the *Riparian Bird Monitoring Report* (EMS, 2008) that tubestock and canegrass planting in 2009 should be undertaken in recommended areas of Barney Creek to augment purple-crowned fairy wren habitat remaining in the area. The Independent Monitor supports this recommendation.

8.6.3 Flora and Fauna Monitoring at Bing Bong Port

Monitoring of the marine environment is being undertaken in accordance with the MRM MMP (MRM, 2008a). The consultant's report regarding elemental concentrations in seawater sediment and biota at Bing Bong (Munksgaard and Gibb, 2009), recommends that the distribution and speciation of arsenic in sediments in the area be further investigated. Furthermore, the concentrations of metals in telescopium and terebralia soft tissue were also found to be elevated in western beach specimens compared to eastern beach specimens (Munksgaard and Gibb, 2009).

The Independent Monitor noted during the December 2008 site inspection that the Bing Bong dredge spoil area did not show significant signs of rehabilitation success. There was poor plant growth and coverage, and a significant number of weed species present. Additionally, it was apparent that saline seepage from the dredge spoil piles is likely to be impacting native vegetation, and potentially native fauna (including the Agile Wallaby and Short-eared Wallaby) adjacent to the area (see Section 7.1.2).

The Independent Monitor does not believe that the AER (MRM, 2009a) provides a satisfactory discussion regarding the dredge spoil area rehabilitation, and does not provide any information regarding future dredging program and associated preparation/ rehabilitation works. It is also unclear to the Independent Monitor as to why the Charles Darwin University research program was postponed due to uncertain future dredging plans, given that trials were being undertaken off-site using dredge spoil that is unlikely to change in composition. The Independent Monitor recommends that this research program be resumed, as the rehabilitation of the dredge spoil area is critical to ensure its long term stability to prevent further off-site impacts.

The Independent Monitor notes that migratory bird surveys undertaken for the Bing Bong and McArthur River estuary have been undertaken and reported within the AER (MRM, 2009a).

However, the Independent Monitor questions the scientific usefulness of continued migratory bird monitoring. It is suggested that the focus should perhaps continue to be on marine sediment monitoring to assess and minimise potential impacts upon migratory birds in the first instance; however opportunistic egg sampling is recommended to continue.

The Independent Monitor concurs with the findings of Charles Darwin University in that there is little scientific benefit to continue the monitoring of migratory birds in the vicinity of Bing Bong Port, and that it will not be possible to detect the effects of heavy metals in the sediments on bird survival. However, the Independent Monitor recommends that the monitoring of potential sediment contamination from Port activities should continue under the Marine Monitoring Sediment Program and the dredge spoil area should be rehabilitated to mitigate potential impacts to migratory birds.

8.6.4 Flora and Fauna monitoring recommendations

The following recommendations have been developed from the Independent Monitor's site-based observations made during December 2009 and June 2009, and the review of results provided in the AER and relevant specialist technical reports commissioned by MRM:

- the number of snags within the river diversions should be increased in number (e.g. double the existing density) to increase fish habitat and control sedimentation within the channel;
- tubestock and canegrass planting should be undertaken in 2009 in areas of Barney Creek to augment Purple-crowned Fairy Wren habitat remaining in the area as recommended by Environmental Management Systems in the Riparian Bird Monitoring Report (EMS, 2009);
- MRM should ensure adequate personnel are available to complete and maintain rehabilitation efforts in the diversion channels and Bing Bong Port;
- fencing around the mine site should be maintained and inspected on a weekly basis to prevent donkeys and cattle grazing within rehabilitated areas;
- ongoing opportunistic migratory bird monitoring (egg sampling) should continue;
- the Bing Bong rehabilitation research program undertaken by Charles Darwin University should not be postponed because of the uncertainty of future dredging plans, as rehabilitation trials can be progressed off-site in the interim;
- increased effort should be made to improve existing rehabilitation of the dredge spoil area to prevent further off-site impacts to native vegetation and potential impacts to birds (including migratory birds);
- the AER should include the assessment of the success of rehabilitation efforts;
- irrigation infrastructure should be installed in all areas of the river channel diversions during the dry season if vegetation exhibits signs of stress;
- assessment and reporting should be undertaken regarding the potential impacts to Barramundi from the river diversions within the next AER; and
- lead isotope analysis of suspended sediments in the McArthur River Delta area be reinvestigated as part of the next monitoring event.

8.7 Review of river diversion hydraulics monitoring

8.7.1 Overview of 2008 Operational Period

The Independent Monitor notes that much of the river diversion construction work was undertaken during the 2008 Operational Period for the McArthur River and Barney Creek diversions. These have since been completed, however, the Independent Monitor notes an absence of documentation that the work has been completed in accordance with approved detailed design plans. This same observation was also made within the previous Audit report (2006-2007 period).

The Independent Monitor has sighted a Connell Hatch letter dated 5 May 2008 (the Independent Monitor notes that the letter year date should actually read 2009), which is a proposal submitted to MRM to undertake a construction report on both the diversions and the main levee. While the letter identifies that the work "could commence at the beginning of June 2009 and completion of the report will take 6 weeks" we have no evidence that the proposal has been accepted. With regard to the Connell Hatch proposal, the Independent Monitor notes that while they appear to have included allowance for reviews to compare the as-built information with the detailed design information, there appears to be no allowance to re-run the design hydraulic (HEC-RAS) models using the as-built details. The Independent Monitor strongly recommends that this flood modelling be included in the detailed reporting of the as-constructed works.

8.7.2 Mining Management Plan 2007-2008

The following section relates to *Section 7*- "*Civil Works"* of the MRM Mining Management Plan 2007-2008 report (MRM, 2008a).

Sub-section 7.2.1 (MRM, 2008a) refers to the works completed for the Barney Creek diversion. During the Independent Monitor's first inspection in January 2008, the Independent Monitor observed that the diversion works, in a general sense, had been undertaken.

Sub-section 7.2.2 (MRM, 2008a) refers to the works completed for the McArthur River diversion. The report identifies that material was removed over a length of 5,265 metres (i.e. Chainage 150 to Ch 5415) and "at each end of the channel the work ceased 150m short of the design channel". The Independent Monitor notes that during the January 2008 inspection there was no access available to this works area, and so the Independent Monitor is unaware of the status of works at that time, or at the end of the 06-07 period.

Sub-section 7.2.4 (MRM, 2008a) refers to "Other Works". One item within this section relates to the two Overburden Emplacement Facility haul road bridges over the Barney Creek diversion channel. It is stated that the first bridge was scheduled for completion "by late November 2007", and subject to approval, the second bridge would be completed "during December 2007". The Independent Monitor notes that during the January 2008 inspection, the first bridge was complete; however the second bridge was still under construction at that time. During the Independent Monitor's second inspection in May 2008 it was observed that the second bridge had been completed.

Sub-section 7.3.2 (MRM, 2008a) refers to the completion of the Barney Creek diversion rehabilitation. One of the items relates to the placement of large woody debris at a number of locations. It is noted that (as also reported in the previous Audit report) that during the January 2008 inspection, the Independent Monitor observed that a significant number of large woody debris had been put in place.

The Independent Monitor has not sighted any documentation that states the number or locations of large woody debris installed. The MMP goes on to state that "the placement of large woody debris in this fashion was approved by DPIFM on the 24thJuly 2007 with a view that modifications would be made if required after the 2007/2008 wet season". The Independent Monitor is not aware of any such review having been undertaken after the 2007/2008 wet season.

Furthermore, as reported in the previous audit report (2006-2007), the Independent Monitor has not sighted details of proposed large woody debris numbers along the McArthur River diversion, nor had any been placed prior to the Independent Monitor's May 2008 inspection.

Sub-section 7.3.3 of the MMP (MRM, 2008a) refers to the McArthur River diversion, within which it is stated that "the re-channelling of the McArthur River will be completed during the period of this MMP". Furthermore, it is stated that this will include the construction of the upstream and downstream tie-ins (at respective Chainages 000-150 & 5415-5565) prior to the start of the wet season. The MMP goes on to state that in addition to completing the tie-ins, a natural rock bar would remain at Ch 400 "to ensure that the majority of the McArthur River normal flow remains within the existing channel" and "this bar will be removed after the 2007/2008 wet season". The Independent Monitor notes that during the May 2008 inspection the following were observed:

- both tie- ins had effectively been completed; and
- part of a rock bar/wall was still in place downstream of the upstream tie-in area. The Independent Monitor does not know when the rock bar/wall was fully removed, however it was not in place during the Independent Monitor's inspection in June 2009.

Sub-section 7.3.3 (MRM, 2008a) also reports that "temporary crossings of the McArthur River will be removed prior to the 2007/2008 wet season". While we have not sighted any documentation about the removal of such crossings, the Independent Monitor observed a temporary crossing in place just upstream of the above mentioned remnant rock bar/wall during the May 2008 inspection. During the June 2009 inspection it was noted that this crossing in the form of a 'ford' (see Plate 5 -, Appendix E) was maintained in approximately the same location as the previous year. The Independent Monitor was advised that the ford had been constructed to facilitate vehicular access to the eastern side the diversion channel so that fence maintenance, environmental monitoring and rehabilitation works can be undertaken; however the Independent Monitor has not sighted for the approval of the ford's construction.

The ford works would most likely have an insignificant impact on the passage of flood flows; however, the same cannot be said for the low-flow regime since the absence of any associated culverts works means that water is forced to pond behind, and then overtop the ford. Although it is recognised that water may flow through the ford structure (with the rate of flow being a function of the material size and compaction of the ford materials), it is considered unlikely that the low flow in the river would match the porosity of the ford structure. Therefore, it is likely that ponding of water behind the ford will occur, which may impact the aquatic flow regime and cause sediment deposition.

Sub-section 7.3.7 (MRM, 2008a) states that the two Overburden Emplacement Facility bridges over Barney Creek would be completed within the 2007-2008 Operational Period. As stated above, we note that the second of the two bridges had been completed prior to the Independent Monitor's May 2008 inspection.

Within Section 7.6 'Environmental Management', the text under Sub-section 7.6.1 'Erosion' (MRM, 2008a) refers to the monitoring of erosion and sediment control measures on an

event basis depending on rainfall, and specific reference is made to the inspections of bund walls “to ensure landform integrity is maintained”.

It is noted that Section 7.6.1 of the MMP (MRM, 2008a) and Item 49 of the MRM Commitment Summary table as provided within MMP Appendix B both provide the same details regarding the monitoring of erosion and sediment control measures. They both state that these will include the following:

- sediment traps to be inspected weekly during the wet season, after all intense rainfall events, and monthly during the dry season;
- damage shall trigger the need for maintenance repairs; and
- quantitative measurement of total suspended solids will be undertake below sediment traps in selected drainage lines.

The Independent Monitor has not sighted evidence of either the as-committed inspections or the quantitative measurements in selected drainage lines during the 2008 Operational Period.

With specific regard to sediment and erosion control works, the Independent Monitor has recently sighted an anonymous February 2007 report entitled *Sediment and Erosion Control Inspection report*. The Independent Monitor considers this report to be a comprehensive report regarding the series of structures constructed in February 2007. The report also lists an additional four structures, which were identified as necessary. As well as an absence of monitoring data, the Independent Monitor has not viewed any information that provides an update on the number of structures that were in place during this audit period.

8.7.3 Annual Environment Report 2005-2008

The civil works completed in 2006/2007 are listed under sub-section 2.5.1 of the Annual Environment Report (AER) (MRM, 2009a). With regard to the Barney Creek and McArthur River diversions, the text implies that essentially all the related civil works have been completed.

The civil works completed during the 2008 Operational Period are listed within sub-section 2.5.2 (MRM, 2009a), which stated that some civil works associated with completing the McArthur River diversion were undertaken during this period. The AER goes on to state that civil works will not be undertaken in 2009 as a range of works including the two diversions “is expected to be completed by the end of 2008”.

It is noted that the AER description of works associated with the two diversions match the descriptions in the 2007/2008 MMP (MRM, 2008a), and are in general accordance with the Independent Monitor’s observations made during January 2008, May 2008 and June 2009.

Rainfall and surface water flow/levels (AER Section 4.3)
The Independent Monitor recommends that an annual review of the relative sizes of wet season flood events and associated review/comments about new erosion trends would be a useful long-term gauge of the performance of the diversion channels, particularly regarding channel bed and bank erosion issues. The Independent Monitor has reviewed the McArthur River upstream gauging station and downstream gauging station plots, which appear as Figures 4.3 and 4.4 under Section 4.3 in the AER (MRM, 2009a). While there are some anomalies in the plots (see discussion below) the two figures both show that for the 07 -08 wet season, the various flood peaks were relatively small (and also smaller than those experienced in 2005-2006 and 2006-2007). However, since the McArthur River diversion

was not complete at the time of the 2007-2008 wet season there is no opportunity to undertake a performance review against those small floods.

While the Barney Creek diversion works were in place during the 2007-2008 wet season, the record of McArthur River flooding does not assist in reviewing flood-related erosion issues along the creek itself. The AER (MRM, 2009a) reports that an additional gauging station on Barney Creek was commissioned in 2008, and that detailed hydrologic and hydraulic (HEC-RAS) modelling of the creek was undertaken for a range of floods (up to and including an extreme flood event) as part of the *McArthur River Mine Open Cut Project Public Environment Report* (URS, 2006). The water level data from the new station will allow historic flood regimes to be compared with the range of 2006-modelled design flood regimes, and hence materially assist in the ongoing review of Barney Creek channel erosion regimes.

With regard to the reporting of diversion channel performances and associated erosion issues, the Independent Monitor recommends that future MMP reports include a review of the previous wet season's water levels within the McArthur River and Barney Creek water levels.

8.7.4 McArthur River flow records

The Independent Monitor's review of data has revealed some anomalies within the two sets of river data recorded at the McArthur River upstream and downstream gauging stations. It was expected that the various relatively small flood peaks recorded at the upstream station would have been consistently replicated at the downstream station, however this is not the case, particularly for the 2006-2007 and 2007-2008 wet seasons where there appears to be fewer flood events being recorded at the downstream station. Given that there are some extra inflows to the river occurring between the two gauging stations (including Barney Creek) there is actually the potential for greater rather than fewer water level spikes being recorded at the downstream station. While the horizontal scale makes it difficult to make an accurate comparison between the flood peak dates, it also appears that the dates also do not correspond. There are two potential reasons for the noted discrepancies:

1. One (or both) of the recorders has malfunctioned in water level measurement and/or time; or
2. local floodplain storage and spread reduces flood peaks before the waters reach the downstream station.

The dry season water level recordings at the upstream station shows a very smooth pattern, however fluctuate for the downstream station (particularly for November 2006-February 2007 & November 2007-December 2007). The above data set concerns are not of great concern if they are only being used for general comparison/review situations, however if the water level/flow data is to be used for other more detailed purposes (e.g. to aggregate total sediment load), it is strongly recommended that an investigation be undertaken regarding these apparent anomalies. However, the Independent Monitor acknowledges that the upstream gauging station is a Government asset, and the downstream station was implemented by MRM and is managed annually by Greenspan.

With regard to assessing changes in wet season flood peaks, it is noted that there may be the opportunity to import some upstream station recorded hydrographs into the project's channel diversion flood (HEC-RAS) model, and compare these (unsteady state) results with the values actually recorded at the downstream gauging station. Since this process was previously followed in calibrating the project's HEC-RAS model to the passage of the January 2003 flood (as detailed in the *McArthur River Mine Open Cut Project Public Environment Report*, (URS, 2006)), such extra investigation is likely to be a relatively straightforward process.

The Independent Monitor notes that while Section 4 of the 2009 Environmental Monitoring Manual (MRM 2009b) describes the procedure for extracting data from all four mine-operated gauging stations, the Manual does not address issues associated with review of the quality of the data.

8.7.5 Review of surface water extraction information

Section 4.3 of the AER (MRM, 2009a) makes reference to extraction of water from the McArthur River in September 2008 to satisfy process water needs. The report states that a combination of a flow meter (which is presumably attached to the extraction pump) and a gauge board "ensured extraction did not exceed 20%" of flow encountered. However, the report does not include a description of how the gauge board system works, and therefore it is unclear whether there can be certainty that the extraction amounts were consistent with the DRDPIFR- approval regarding extraction, indicating extraction must not exceed 20% of the concurrent flow.

Similarly, while the AER (MRM, 2009a) also reports that the total extracted volume was 2.3 ML figures do not provide any information regarding rates of extraction throughout the period when water was being extracted. However, if information was available regarding pump operating times and associated pumping flow rates, this information would assist in confirming the percentages of concurrent flow extracted.

8.7.6 Health Safety Environment and Community (HSEC) Checklists

The Independent Monitor has reviewed the two MRM HSEC Checklists dated August 2008 and November 2008 relating to river diversion inspection, and the following comments are offered:

- checklists are considered to be only very general in nature; and
- while both 'end scores' appear commendable, they are quite misleading if they are being presented as evidence of achieving a high level of performance or compliance.

With regard to the latter comment, the checklist includes a number of questions which relate to evidence of weeds or erosion and in each case the answer filled in is "Yes". However this answer then has an accompanying score of "1" rather than "0" – hence contributing to the inflated end scores - and additionally (and crucially) no comment appears in the adjacent 'Non Conformance' column. However, based on updated information provided by MRM, it is understood that HSEC inspections have now been changed to incorporate a scoring system which alleviates this issue.

8.7.7 Barney Creek and McArthur River Diversion photographs

We have sighted the portfolio sets of channel photographs that have been taken along the Barney Creek diversion from the southern top of bank (in July 08 & March 09) and the McArthur River diversion from the western top of bank (in October 08 & March 09). It should be noted that these photographs extend beyond the 2008 Operational Period of audit focus.

These photographs are considered to be a valuable tool for reviewing short and long term changes along the watercourses, and as seen in Section 18 of the 2009 Environmental Monitoring Manual (MRM,2009b) these photograph portfolios (based on photographs taken before and soon after each wet season) document erosion along the river diversion channels. The Environmental Monitoring Manual (MRM, 2009b) states that the photographs will be used to "determine the location of any affected areas and identify any sections that require additional works to rectify any damage and prevent future erosion". Furthermore it is stated that a report will be produced by MRM staff detailing the level of works required, such as additional revegetation, earthworks and/or rock armouring.

It is presumed that details of diversion channel erosion monitoring and as-necessary associated remedial works will be provided in each subsequent MRM reporting period.

During the June 2009 inspection, the Independent Monitor noted what appeared to be two new bank erosion/slumping issues at two locations along the McArthur River diversion (see Plate 5 -Plate 6 - Plate 7 -Appendix E). It is recommended that a review be undertaken of the post 2008/2009 wet season photograph portfolio of the McArthur River in order to confirm that the photographs do capture the bank issues shown in Plate 6 - and Plate 7 - (Appendix E). If the photographs cannot be sighted or there is a lack of clarity in the images (due to their locations being midway between two designated photo locations), it is recommended that a review be undertaken regarding the adequacy of the spacing of the designated photograph locations.

It is recommended that the each of the future reports on diversion channel erosion include a review of the previous wet season McArthur River and Barney Creek flood events/levels since, so that the longer-term picture of scour can also be reviewed against relative flood magnitudes.

It is clear that the photograph portfolios will also assist in broad scale monitoring of the rehabilitation works. For example, a review of the triple July 2008 and March 2009 photographs taken at Barney Creek Ch 500m (see Plate 8 -and Plate 9 - Appendix E) reveals that while the 2009 vegetation at the top of the channel banks is denser and more established, the previous (July 2008) vegetation and soil has been lost from the lower section of the channel bank. Moreover, there is a distinct near horizontal line defining the upper limit of the soil loss, which suggests that the soil loss may be directly related to the passage of a recent flood. While it is noted that the *Rechannel Rehabilitation Plan* (MRM, 2009c) provides details of initial rehabilitation works, there does not appear to be any consideration of works that involve re-working of rehabilitated areas other than “additional infill planting may be required depending on the results of surveys”(MRM, 2009c:6).

Rechannelling Rehabilitation is also detailed in Section 7.4 of the 2007-2008 MMP (MRM, 2008a) and under Sub-section 7.4.3 “Monitoring” the importance of monitoring the revegetation works is highlighted. The details of the proposed monitoring plan given in Sub-section 10.4.8 “Monitoring of Re-channelled Rehabilitation” (MRM, 2008a) emphasises the measurement of vegetation in the specific plot locations. This section states that certain minimum density of plants (including 5000 stems/plants per hectare after 12 months) will be used to assess the requirement for replanting or investigating trialling of other rehabilitation techniques. It is understood that the plot monitoring will be undertaken by Charles Darwin University and it is noted that their April 2008 report is focused on background reporting of riparian vegetation communities away from the diversion channel works.

Based on the above approaches provided within the MMP (MRM, 2008a) and Rechannel Rehabilitation Plan (MRM, 2009c), it is clear that plot surveys will provide the mechanism for addressing the potential need for re-establishment/replanting of channel bank vegetation. This will presumably include scenarios such as the large-scale soil loss adversely impacting the target minimum plant density numbers.

It is recommended that similar photograph sets be taken at the same chainages for Barney Creek and McArthur River, but from the opposite banks so as to provide a complete picture of short and long term erosion trends along both diversion channels.

8.7.8 Wet season flood spill

During the June 2009 inspection, MRM personnel referred to the observed passage of some 2008-2009 wet season flood flows spilling from the remnant McArthur River channel (upstream of the main levee wall) and passing overland to the new diversion channel (see Plate 10 - Appendix E). McArthur River Mining verbally reported some accompanying scour as the floodwaters both travelled overland to the diversion channel and spilt (*i.e.* dropped) into the diversion channel. The magnitude of the above event is unclear, however the Independent Monitor considered it unlikely to have been a large (*i.e.* rare) flood. The long-term implications (particularly related to scour) are unclear, however is recommended for on-going monitoring and as-necessary rehabilitation works.

The Independent Monitor notes that this issue does not appear to have been addressed in the earlier URS 2005/2006 project flood modelling since those HEC-RAS hydraulic models do not appear to include a separate model flow-path to allow assessment to be undertaken of this particular overland flow regime.

8.7.9 Barney Creek diversion work monitoring

With regard to Barney Creek, the URS 2006 McArthur River Mine Open Cut Project Public Environment Report (PER) (URS, 2006:5-25) states that:

> …the diversion channel is designed to be a permanent feature of the landscape, and as such should have the means of conveying not only the design flood flows (2 year to 100 year ARI floods), but also the extreme flood events without compromising the stability of the diversion channel.

The report goes on to state how the diversion works will be designed to withstand stream powers for events up to and including a 50 year ARI flood and that:

> …MRM would accept the risks associated with floods larger than a 50 year ARI during the life of the mine. Potential risks would include the loss of non -established vegetation and rock and topsoil mixtures. In such an event, MRM would reinstate the vegetation and the rock and topsoil mixture as per the vegetation management plan. (URS, 2006:5-25).

Table 5.1 in the same URS (2006) report lists a number of conclusions regarding the Barney Creek diversion works. They include the following:

- the diversion channel will have a similar hydraulic performance to the existing creek and will convey similarly sized bank-full flood flows;
- the diversion channel will be stable over the mine life and beyond including for local flood events with no concurrent flooding in the McArthur River; and
- the channel diversion will not be subject to significant erosion or sediment deposition.

The report also identifies rehabilitation strategies which include the following:

- planting in topsoil that has been placed within rock- lined banks along the diversion channel to prevent the topsoil being washed away;
- implementation of an effective maintenance program including fertilizing, watering and weed control; and
- implementation of an effective monitoring and replacement program.

It is understood that the above commitments listed in the 2006 PER (URS, 2006) will be monitored

through the erosion and rehabilitation monitoring procedures discussed previously in Section 8.7.7

8.7.10 McArthur River diversion works monitoring

Table 4.1 in within the PER (URS, 2006) lists the following conclusions regarding the McArthur River diversion works:

- the diversion channel will have a similar hydraulic performance to the existing river and will convey similarly sized bank-full flood flows; and
- the diversion channel will be stable over the mine life and beyond, and will not be subject to significant erosion or sediment deposition.

The report also identifies rehabilitation strategies which include:

- planting in topsoil that has been placed within rough rocky banks along the diversion channel to prevent the topsoil being washed away;
- provision of soil and fine sediment in the porous substrate on the channel banks to encourage root development and sustain moisture for plant establishment and survival;
- provision of topsoil in the bank cover rock to provide a medium for root development and moisture retention through alluvial materials;
- implementation of an effective maintenance program including fertilizing, watering and weed control; and
- implementation of an effective monitoring and replacement program.

The Independent Monitor questions whether the lack of progress with rehabilitation/re-vegetation works has significantly impacted on the above expectations, including measures to retain and protect soil from being lost.

The Independent Monitor notes that the PER (URS, 2006) does not include any explicit channel design flood stability criteria, however does state that “stream power has been used as a measure of the potential for long -term stability of the McArthur River” (p.4-42). The report does list the numerous design changes that were made to the 2005 flood model in order to “reduce the potential for impacts to the McArthur River system both upstream and downstream of the diversion channel and for impacts to the diversion channel itself” (URS, 2006:4.42).

It is understood that the above commitments listed in the PER (URS, 2006) will be monitored through the erosion and rehabilitation monitoring procedures discussed under Section 8.7.7 of this report.

8.8 Review of civil works monitoring

8.8.1 Tailings Storage Facility pipeline over Barney Creek

Photograph Plate 11 - Appendix E shows the newly installed (since the 2008 audit period) protection shroud covering the Tailings Storage Facility pipeline over the Barney Creek channel crossing. The shroud, along with the pipeline, slopes towards the channel crossing abutment on the Tailings Storage Facility side, which is the point at which the slurry will run out, should any leaks occur in the pipeline over the crossing.

The Independent Monitor notes that the abutment has not been bunded around the pipeline, and as a result, any noticeable volume of leaking slurry is currently not prevented from flowing back into Barney Creek. McArthur River Mining personnel present during the inspection indicated that prior to the start of the next wet season, MRM have scheduled to construct a containment bund on this abutment. The Independent Monitor was advised that the pipeline is checked every six hours for evidence of leaks and flow meters are proposed for installation at either end of the pipeline as a means of continuously monitoring the integrity of the pipeline. McArthur River Mining personnel advised the Independent Monitor that the pipeline inspections, which are not formally documented, generally consist of a drive-by inspection, whilst more detailed inspections of footings etc., are not routinely completed.

The Independent Monitor did not review monitoring documentation regarding the Tailings Storage Facility pipeline in detail, as the documentation provided related primarily to the monitoring of the tailings slurry and the structural aspects of the pipeline. The geotechnical considerations for the pipeline are related to the suitability of the pipeline footings and ensuring that differential settlement cannot cause pipeline rupture. It is understood that the pipeline has been in service for some time and no specific work was done on the footings during the audit period.

8.8.2 Tailings Storage Facility

Tailings Storage Facility geotechnical considerations

The Tailings Storage Facility inspection undertaken by the Independent Monitor during June 2009 was confined to:

- the central section of the northern embankment of Cell 1;
- the Surprise Creek channel bank adjacent to the central section of the northern embankment of Cell 1; and
- the central section of the internal wall separating Cells 2 and 3 from Cell 1.

McArthur River Mining have advised that the dam is inspected biannually by external consultants (Allan Watson and Associates), who provide an annual inspection report which:

- documents the condition of the dam as observed during the inspections; and
- reviews all available information pertaining to the dam, with particular focus on the monitoring and surveillance information recorded by MRM during the pertinent year.

The information provided to the Independent Monitor indicates that Allan Watson Associates inspected the Tailings Storage Facility once during August 2008. However, MRM have advised that MRM personnel complete driving inspections of key areas of the Tailings Storage Facility such that the dam is inspected daily by at least one MRM representative. Areas of concern are identified during these inspections are documented and considered for remediation; however, based on the process description, it is unclear whether these in-house inspections are performed (or documented) in a systematic manner to effect continuity between the various 'inspectors' having an understanding of the condition of the Tailings Storage Facility. As such, it is possible that areas of deterioration may remain unidentified for extended periods of time.

Photograph Plate 12 - Appendix E shows the downstream mid-northern embankment of Cell 1, where some small shrubs have established themselves. It is understood that MRM, as recommended by Allan Watson Associates, have previously removed larger trees and shrubs, which the Independent Monitor considers to be good dam engineering practice. The grass cover and small vegetation cover of the downstream embankment is patchy in places, and without rock protection it is possible to see advanced rutting in several locations across

the downstream batter. Based on the provided documentation (monthly inspections), it is noted that MRM has remediated (with crushed rock) some areas where identified rutting had become unacceptable.

From the small section of the Surprise Creek embankment inspected (at the northern outer section of Cell 1), it is considered that the overall condition of the downstream embankment is generally acceptable. However it will be important to maintain grass / small vegetation cover and or rock protection to ensure that erosion gullies are not allowed to form into significant features. It is noted that Cell 1 has a history of piping failure, deep rutting partially attributed to dispersive soils (Australian Mining Engineering Consultants, 2003).

Following review of the *Final Report – McArthur River Mine Tailings Storage Facility Rehabilitation–Cell 1 Concept Design, URS Report dated 10 December 2004* (URS 2004) the following is noted:

- Table 4.1 (URS, 2004) notes that as part of condition 12 (Lease 1121-5) MRM is required to submit a complete rehabilitation proposal, prior to decommissioning of the TSF. The Independent Monitor is not aware if a 'complete' rehabilitation proposal been prepared;
- Section 9 (URS, 2004) discusses the long-term steady-state stability of the embankment and indicates that the current slope of the embankments (which are around 1H(height):1V(vertical) to 1.5H:1V) are steeper than the original design of 2H:1V;
- URS (2004) indicates that only limited data set was available and that the parameters (both material properties and phreatic water surfaces) used in their stability assessments would need 'confirmation during the detailed rehabilitation works'. Even so, using the assumed parameters, URS note that even if the embankments are flattened to 2H:1V, if the phreatic surface is able to rise, then the factor of stability becomes less than the ANCOLD requirement of 1.5; and
- URS investigated options for improving the landform (constructing a stabilising berm or flattening the slope) and determined that if the flattening option were to be adopted in order to get a factor of stability of >1.5, then the existing embankments would have to be flattened to 4H:1V.

If a complete rehabilitation proposal has been prepared' the Independent Monitor will review this as part of next year's audit.

McArthur River Mining confirmed that the Cell 2 embankment does have some monitoring installations within the embankment (monitoring bores), however Cell 1 does not. As such, MRM are unlikely to have an understanding as to the likely phreatic surface conditions within the cell and the embankment. It was noted that the embankment does not have any monitoring pins installed across it (standard practice) and MRM confirmed that the Tailings Storage Facility embankment structure is not routinely surveyed to identify indications of bulging or movement. Allan Watson Associates annual reports also identify this as an area of deficiency, but rather visual inspections are relied upon for this identification.

Photo Plate 13 - Appendix E shows the crest of the northern embankment of Cell 1 (approximately midway along), with ponded water in the foreground and the clay capping in the background, which has been placed partly as a clay capping trial and partly to suppress dust until the final clay capping can be placed. The section of embankment crest walked (and area of clay capping) did not exhibit any evidence of cracking other than surficial cracking. The Independent Monitor observed that the clay capping (over approximately 2/3 of Cell 1) is composed of variable clay material with varying degrees of thickness, with

tailings material seen to be exposed in some areas. One of the reviewed documents indicated that the required capping thickness was to be 500 to 600mm, although the Independent Monitor considers that this thickness may have been reduced for the trial.

It is important to note that whilst the trial clay capping appears to be working well as a dust suppressant, it cannot be considered to be functioning as an impermeable barrier to limit infiltration of rainfall. As such, the phreatic surface must be considered when assessing the stability of the embankment (although what the phreatic surface should be is difficult to estimate without some field data). McArthur River Mining personnel also indicated during the site inspection that the clay capping was placed without compaction control.

Photograph Plate 14 -Plate 15 -Plate 16 - Appendix E provide the observed evidence of active seepage that is occurring under the northern embankment. In each of these plates, significant salt crystallisation can be seen deposited on the surface and closer inspection of the extremely weathered rock where the mineral is deposited found the rock matrix to exhibit evidence of advanced breakdown. In particular, Plate 16 - Appendix E indicates that the seepage may be occurring along the interface between the soil and rock and therefore possibly passing under the polymer cutoff trench. Given the observed deterioration within the matrix of the exposed rock on the Surprise Creek channel embankment, and the possible presence of dispersive soils (previously reported) it is considered possible that the rate of seepage may increase (until a correctly constructed clay capping can be placed) as the migrating fluids continue to 'erode-out' the subsurface material.

The Tailings Storage Facility is composed of embankment structures of various ages and is annually inspected by external consultants (currently Allan Watson Associates), with more regular, although not systematic, inspections and monitoring completed by MRM personnel. Based on the information that was provided just prior to completion of this report (Australian Mining Engineering Consultants, 2002, 2003, 2004; Klibbe, 2003; Klenowski, 2004) and considering the field observations around the banks of Surprise Creek it is understood that the Tailings Storage Facility embankments (in particular Cell 1) have had, and continue to have, significant geotechnical and environmental issues of concern.

The Independent Monitor notes a lack of continuity between the routine MRM inspections and the Allan Watson Associates inspection observations. The 2007-2008 MMP (MRM, 2008a) does not indicate a high frequency of inspections undertaken in and around the Tailings Storage Facility. Based on the documentation provided, it appears that these inspections are somewhat haphazard (i.e.: no guarantee that every area of the dam is regularly being visited) and poorly documented, and seem to lack consistency given that they rely solely on visual observation and that a number of people are completing the inspections. This level of day-to-day monitoring and surveillance is not in accordance with the Australian National Committee on Large Dams (ANCOLD) guidelines for a high hazard category dam.

The Allan Watson Associates Tailings Storage Facility Dam Safety Reviews for 2005, 2007 and 2008 (Allan Watson Associates, 2005; 2007; and 2008) were provided to the Independent Monitor for review. The following general comments are made regarding the Allan Watson Associates Dam Safety Reviews:

- The Allan Watson Associates annual reports do not constitute a 'Dam Safety Review' in accordance with the ANCOLD guidelines, but are rather annual inspections. A Dam Safety Review is normally completed after a facility has been operating for 10 or 20 years, and/or after a comprehensive dam inspection (by dam experts) has been completed (typical frequency is every 5 years or in response to an identified issue with the dam). As some Cell 1 design information was requested and received outside of

the review period, the Independent Monitor will evaluate this background information as part of the 2008-2009 Audit report;

- Based on field observations and review of available data, a comprehensive Dam Inspection and Dam Safety Review is warranted. Broadly, a Dam Safety Review should also include a review of the design of the dam embankments (or investigation if the design of the dam is not documented), and possible remedial works to rectify any identified areas of safety risk (e.g. stability, piping failure, spillway inadequacy, liquefaction etc);
- Based on discussions with MRM personnel, and the review of some design information provided to the Independent Monitor, it is understood that there are no monitoring bores within the Cell 1 embankment, however some installations in the Cell 2 embankment do exist. This information does not appear to be considered by Allan Watson Associates in the annual review. Furthermore, it is understood that MRM do measure the water levels, but it is unclear whether the monitoring bores are being read according to the prescribed frequency (monthly) and how the data is assessed;
- It is noted that some significant recommendations in the Allan Watson Associates 2005 annual report are still repeated in the 2008 annual report (e.g. spillway capacity review, embankment phreatic surface monitoring and assessment in relation to stability etc) (Allan Watson Associates, 2008). This shows that MRM have been slow to action recommendations which have a significant impact on how well the owner understands their facility and how they can manage the ongoing functionality of the facility;
- One of the review outcomes listed in the 2008 Allan Watson Associates annual inspection is the recommendation to install monitoring survey pins around the Tailings Storage Facility so that the dam stability can be quantifiably monitored. Given the potential environmental risks associated with this facility, a system that quantifiably monitors the condition of the embankment would be considered beneficial by the Independent Monitor.

During the finalisation of this audit report, the Independent Monitor was provided with some additional documentation regarding the design of the Tailings Storage Facility Cell 1 embankment in the design documentation for raisings (Australian Mining Engineering Consultants, 2002, 2003, 2004; Klibbe, 2003; Klenowski, 2004) which in addition to the Allan Watson Associates construction report for stage 2 provides a reasonable snapshot of the design and construction aspects of the overall Tailings Storage Facility. The Independent Monitor recommends that the following documents also be integrated into subsequent Dam Inspection and Safety Review reports:

- Copy of Maunsell McIntyre August 2000 (Ref No. 15000300) design report for Stage 1 Design Report for the Proposed Raising for Cell 1 of the Tailings Dam;
- Copy of Maunsell McIntyre April 2001 (Ref No. 15000300) design report for Cell 1 Tailings Dam Raising Stage 3 Design Report;
- Copy of Allan Watson Associates February 2007, Tailing Storage Facility Cell 2 Design; and
- Any other design and construction reports for the Tailings Storage Facility (including the Water Management Dam).

The Independent Monitor could not find reference to a specific Dam Emergency Response Plan within any documents reviewed, or within the *Tailings Storage Facility Operating Guidelines* (MRM 2007i). The Independent Monitor would like to see evidence of a Dam Emergency Response Plan (if it exists) during the next Audit period, as this is an ANCOLD

requirement for high-hazard dams. The Independent Monitor also notes a lack of evidence to indicate that emergency response drills had been practiced for the Tailings Storage Facility.

Although the Independent Monitor understands that the observed rehabilitation trials undertaken on Cell 1 of the Tailings Storage Facility were preliminary in nature and also used as an interim dust suppression method, monitoring of the geotechnical considerations of these works and future rehabilitation trials is recommended.

Tailings Storage Facility geotechnical recommendations
The following recommendations are based on information gained from the Independent Monitor's site inspection and review of documentation regarding the Tailings Storage Facility:

- A complete comprehensive Tailings Storage Facility inspection and Dam Safety Review should be undertaken in accordance with relevant ANCOLD guidelines. According to the ANCOLD guidelines, the Independent Monitor considers the Cell 1 embankment to be overdue for a comprehensive inspection, and Dam Safety Review, due to time that the facility has operated, and given the potential associated environmental risks. The Dam Safety Review should also assess the spillway adequacy for Cell 1 and the Water Management Dam (raised by Allan Watson Associates in the annual inspections repeatedly), the various embankment construction and stability and the operating procedures (including dam emergency response plan).
- The Independent Monitor advises that recommendations made by Allan Watson Associates be implemented by MRM, including:
    - installation of groundwater monitoring boreholes in all embankments (where not present); and
    - installation of survey pins at key locations around the dam perimeter.
- The Independent Monitor recommends that MRM increase the monitoring regime to be more in compliance with the relevant ANCOLD monitoring guidelines for high hazard category dams.

Tailings Storage Facility geochemical considerations
The Independent Monitor conducted a detailed inspection of the Tailings Storage Facility and also reviewed laboratory compiled data for monthly monitoring of tailings for pH, acid neutralising capacity (ANC), net acid production potential (NAPP), net acid generation (NAG) at pH 4.5 and 7, and maximum potential acidity (MPA) for 2007-2009.

As described in Section 7.1, notification was provided to MRM and DRDPIFR by the Independent Monitor that the tailings within Cell 1 had, and are continuing to oxidise rapidly, and producing sulfuric acid (H_2SO_4).

The geochemistry results for this period indicate that up to 20% sulfur could be present in the tailings of both Cell 1 and Cell 2. The NAPP calculations, which are based on the difference between ANC and %sulfur, were strongly positive (>350 kg sulphuric acid/tonne). Furthermore, the pH of tailings recently deposited in Cell 2, 2.4 in September 2008, indicates that the tailings have already acidified upon deposition. Discussions with Stephen Pevely (personal communications) (MRM) indicate that recent changes in the metallurgical process are likely to account for the increasing sulfide content in tailings rather than the processing of ore that contains more pyritic materials.

However, the NAG and NAGpH results do not indicate a significant potential to produce acid, which may be due to the fact that NAPP reports all sulfur as 'sulfides', and does not consider

the presence of oxidised or oxidisable sulfur (sulfates) or non-acid producing sulfides such as galena and sphalerite. Therefore, the reliance on either NAPP or uncalibrated NAG values alone to predict the future generation of acidic leachate is problematic at best.

Furthermore, calibration between the two methods for the presentation of kinetic column leach data is not evident, although a commitment to undertake this is provided in the MMP (MRM, 2008a) and AER (MRM, 2009a). That acidic leachate is evident within both Cell 1 and Cell 2 of the Tailings Storage Facility, and iron sulfate salts existing on exposed tailings in Cell 1, indicate that the NAF (non-acid forming) classification accorded to the tailings in Section 4.13 of the AER (MRM, 2009a) is incorrect.

Although the amount of acid generated does not appear to be in the order of 350 kg sulphuric acid/tonne as purported in the NAPP tests, it is greater than that reported in the NAG tests and as such, the amount and rate of acid generation is not adequately known.

Tailings Storage Facility geochemical recommendations
The Independent Monitor provides the following recommendations for improving the environmental performance of the McArthur River Mine with respect to the monitoring and management of tailings geochemistry:

- install piezometers in Cell No 1 along a transect from the south/south-western boundary of Cell 2 (through the dividing wall) to the observable salt discharge at Surprise Creek, with care to ensure that the cell liners are not breached;
- collect undisturbed samples at 0.5 m intervals and analyse for porosity and density. If the samples are saturated, measure pH, redox potential (Eh) and total dissolved salts (TDS) of the saturated sample (water) in the field. If the samples are dry, measure pH using Raupach or 1:5 method. The electrolytic conductivity of the dry sample should also be determined using the 1:5 method;
- undertake field measurements within the piezometers to determine the hydraulic conductivity at each location;
- collected samples from drilling be analysed for total oxidisable sulphur (TOS), net acid generation potential (NAGP = TOS - ANC) and mineralogy, particularly % sphalerite and % galena and % acanthite/argentite. Calculate an adjusted NAGP by subtracting % sulfur associated with sphalerite and galena;
- undertake kinetic testing on collected samples using a 0.1 M sulphuric acid solution on a 12-hour wet & dry (heat lamps) cycle. Calculate the pore volume and measure the volume of leachate generated from the base of the kinetic columns in relation to the pore volumes. Measure cloride, sulphate, lead, cadmium, pH, electrolytic conductivity, and redox potential in the leachate at the base of the column;
- collect samples of the water in the piezometers and analyse for pH, total dissolved salts, cations (sodium, calcium, magnesium, potassium, ammonium) anions (chloride, bicarbonate, sulfate, nitrate, phosphate, and fluoride) and dissolved heavy metals (aluminium, arsenic, cadmium, chromium, copper, iron (Fe^{2+}/Fe^{3+}/total Fe), mercury, manganese, lead, nickel and zinc). Field measurements for pH, electrolytic conductivity, redox potential, temperature and dissolved oxygen, and observations of colour, odour, yield, etc are required;
- collect samples from representative uncontaminated alluvium and undertake batch tests to derive retardation coefficient (K_d) values for cadmium, lead, zinc, and hydrogen ion;

- using the measured bulk density, porosity, gradient and permeability of both the alluvium and tailings, derive attenuated velocities for hydrogen, cadmium, lead and zinc; and
- using simple 1-dimensional models, measure the potential for acid and heavy metal breakthrough at Surprise Creek under different potentiometric head conditions and estimate the mass balance and amount of seepage over time.

MRM should not change their current tailings management practices of Cell 1 until the outcomes of the investigation are known. These recommendations form part of the notification for investigation presented in Section 7.1.1.

8.8.3 Sump area at toe of Run of Mine Pad

The toe of the Run of Mine (ROM) area was inspected by the Independent Monitor during the June 2009 site inspection. It is understood that one of MRM's environmental incidents occurred at the ROM pad sump during the last wet season (2008/2009), where the pump installed within the sump failed immediately after a period of prolonged rainfall. The failure of the pump caused runoff from the ROM to discharge over the access road and into the adjacent Barney Creek. It is understood a small part of the road embankment at the point of breach was mostly washed away.

Photograph Plate 17 -and Plate 18 - Appendix E show the newly-reconstructed sump as at June 2009 (the pump is yet to be installed) and the reconstructed access road immediately down slope of the sump. The Independent Monitor has viewed MRM's incident reports relating to this event and believes the MRM incident reporting procedure was effective. However, the Independent Monitor questions whether the remedial works will eliminate recurrence in the future, as the remedial solution appears to be the same as the previous arrangement, which relies on a pump to be functional with only a small sump (albeit slightly larger than previously) to collect water. Furthermore, although the road has been reinstated, the Independent Monitor notes that the sump (at the time of inspection) did not appear to have a designated low point (ie a spillway or decant pipe that is protected) to direct any overflow. It was also noted that at the time of site inspection, that the crushed rock from which the reconstructed road is made appeared to be poorly graded and the small embankment batter face did not appear to be well protected by rock armour against scour. However, the Independent Monitor understands that at the time of site inspection the sump remediation was not completed, and has since undergone further works. The effectiveness of the remediated sump will be review during the Independent Monitor's next site inspection in 2010.

8.8.4 River Diversions

Geotechnical considerations

Based on the Independent Monitor's inspection of Barney Creek near the intersection with Surprise Creek, and the upper McArthur River diversion, the following comments are provided with regard to Barney Creek / Surprise Creek (Plate 19 -Plate 20 -Plate 21 -Plate 22 - Appendix E):

- overall the rip rap appears to have performed generally well, although it is understood that it has only experienced one wet season. The channel banks are steep, which indicates that the thickness of the rock armour layer is relatively thin and areas have already developed with minor slumping of the rock armour (Plate 20 -Plate 21 - Appendix E). It is uncertain as to what grading of rock armouring was used, and the flood flows for which the armouring is designed. The Independent Monitor anticipated that this information will exist in the design reports and the yet to be completed as-constructed reports; and

- Plate 22 - Appendix E shows a section of Surprise Creek that did not have rock armour at the time of inspection. This plate indicates that advanced scouring has already occurred at this area. The Independent Monitor considers that this is likely to continue until the bank is reshaped in accordance with the general direction of flood flow.

It is anticipated that the banks of Barney Creek and Surprise Creek channel diversions will continue to deteriorate when exposed to further wet seasons until the banks reach a general state of equilibrium with the flood flows. To remediate these banks is likely to be relatively expensive and considered unwarranted unless there are areas of land behind the sections of bank that must be maintained. If remedial works are required, given the steep profile of the banks it is suggested that consideration be given to a re-designing the profile rather than only replacing rip rap dislodged during the preceding wet.

The following comments are provided with reference to the McArthur River Diversion (Upstream End) Plate 23 -Plate 24 -Plate 25 -Plate 26 - , Appendix E:

- the sections of the McArthur River diversion inspected appeared to be generally in good condition with only minor silting of some chutes and some small rock failures observed (Plate 24 -Plate 25 - Appendix E);
- the rockier sections of the river diversion (upstream end) appear to be in generally good condition, although some small-scale rock fall can be seen where softer material has been washed/eroded out leaving the remaining exposed blocks to become unstable. As recommended previously for Barney Creek, unless it is important to maintain the diversion channel crests at their current location, the Independent Monitor does not consider the deterioration of the crests and flattening of the channel banks to a more natural angle to pose a significant geotechnical-related environmental risk in the short or medium term;
- during the Independent Monitor's June inspection, MRM advised that during the last wet season, the flooded McArthur River flow continued into the old natural river course before hitting the mine levee and being turned overland to the northwest and re-entering the diversion downstream (see Section 8.7.8 and Plate 10 - Appendix E). At the time of the inspection, any damage caused to mine levee and the crest of the river diversion where the flood waters re-entered the system had been remediated. The Independent Monitor requested to see the incident report relating to this event; however this was not provided in time to be considered for this report. The Independent Monitor is unclear as to the design criteria for the mine levee and consequently, is unclear as to the geotechnical risk the McArthur River breaking it's diversion banks such as this incident; and
- the Independent Monitor notes that there are currently no as-constructed drawings or reports available for the McArthur River diversion works for geotechnical review.

River diversion geotechnical recommendations
Based on the inspected sections of the river diversions, it is recommended that ongoing targeted monitoring be continued, however there does not appear to be any obvious environmental hazards associated with geotechnical aspects that can be identified for the short to medium term. It is noted that the as-constructed drawings and/or construction reports for the river diversions have not been completed. Review of these documents may raise queries that were not apparent during the visual inspection.

Based on the site inspection and documentation review the Independent Monitor provides the following recommendation regarding geotechnical considerations for the river diversions:

- McArthur River Mining should ensure that as-constructed drawings and reports are finalised and are provided to the Independent Monitor for review within the next Audit report in 2010; and
- areas along the diversion channels for which it is critical that channel crests are to be maintained, should be adequately armoured with rock. Visual monitoring of the diversion channels should also be continued, with particular focus on any areas identified as being critical to the ongoing performance of the diversion channels.

8.8.5 Overburden Emplacement Facility

Geotechnical considerations

The Overburden Emplacement Facility has been designed to encase potentially acid-forming rock (PAF) in non acid forming rock (NAF) and acid consuming rock (AC). Photograph Plate 27 - Appendix E shows the Overburden Emplacement Facility at the time of the inspection.

However, based on the information provided by MRM, including the URS Overburden Emplacement Facility final design report (URS, 2008b), it appears that quality control procedures undertaken during the construction of the Overburden Emplacement Facility, particularly with regard to the clay lining, is not adequate.

During the site inspection, the MRM Mining Manager indicated that the clay liner had been placed without any direct quality assurance/quality control supervision and documentation. McArthur River Mining later confirmed (via personal communications) that no direct testing had been undertaken for the placed clay liner, however, indicated that testing had been undertaken on the clay used in other civil works, which was from the same source as the clay used to line the Overburden Emplacement Facility, and as such, MRM is satisfied that the material was placed correctly.

Following the review of the Final Report for the Overburden Emplacement Facility (URS, 2008b), the following information was obtained regarding the testing of the clay liner:

- Section 2, Table 2.3 (URS, 2008b) states that the clay samples tested in the investigation for the Overburden Emplacement Facility had a permeability of $2\text{-}3x10^{-10}$ m/sec when compacted to 98% of standard maximum dry density, however the moisture content is not stated. It is also stated that the tested permeabilities exceed the general industry acceptable criteria for liners of $1x10^{-9}$ m/sec.
- Section 3.2 of the URS (2008b) report directs how the clay liner is to be constructed and specifies, a lift thickness and compaction requirement within a certain moisture content range. All of these requirements are quantifiable, and for a liner construction project it is standard practice to have this carefully supervised, quality control tested, and certified. Specification details for the clay are also detailed within Appendix F (URS, 2008b); and
- The report also discusses the need for quality control in terms of material parameters and the need for quality control testing (URS 2008b - Appendix F, Section 1.4, Section 2.1 A & B, Section 3.2 and Section 3.3).

Clay liner permeability is a function of material composition, moisture content, density and thickness, and it is standard industry practice that the liner must be verified for acceptability through site testing. This does not appear to have been undertaken in line with URS recommendation (URS, 2008b). Without this testing the Independent Monitor cannot comment as to whether the Overburden Emplacement Facility design intent has been met.

In order to verify that the clay liner meets design requirements, an investigation and sampling program including an adequate density of sample points, may be required. Alternatively, a borehole monitoring field around the Overburden Emplacement Facility may be considered. The Independent Monitor notes that if the clay liner is not performing to design intent, then any leakage of contaminants may have been occurring for a considerable period of time.

Overburden Emplacement Facility geotechnical recommendations
The Independent Monitor provides the following recommendations regarding geotechnical considerations for the Overburden Emplacement Facility:

- a review of the previously completed PAF cells should be undertaken along with an investigation to determine whether the clay liner and foundation meets the design intent of the URS final Overburden Emplacement Facility design;
- McArthur River Mining should ensure that for all future cell construction, the clay liner is placed under Level 1 supervision. Alternatively MRM may commission URS to determine a revision to the design to compensate for the situation of no supervision, *i.e.* "overdesign" and provide field indicators that operators can use to confirm clay liner suitability with periodic confirmation testing; and
- the Independent Monitor advises MRM to continue with the PAF and NAF material sampling and confirmation program to ensure that PAF material is placed correctly.

Overburden Emplacement Facility Geochemical Considerations
As part of the 2007-2008 monitoring period review, the Independent Monitor was provided with examples of procedural system documents used in the waste classification of materials for the Overburden Emplacement Facility. These procedures included civil works rock sampling procedures, ore grade control procedures, results of waste classification testing, rock sampling data sheets, a job safety analysis (JSA) for undertaking rock sampling, and the URS Overburden Emplacement Facility design report (URS, 2008b).

The quality control in terms of PAF identification, placement and verification appears to be reasonable as documented in the Overburden Emplacement Facility cross section survey reports provided to the Independent Monitor (listed in Appendix F) and the *Mine Technical Services – Ore Spotting and Grade Control* protocol (Tilley and Joseph, no date).

Examples of PAF/ NAF confirmation sampling undertaken during 2008 were provided to the Independent Monitor. These sampling results correlate with the observations made by the Independent Monitor during the June 2009 inspection.

The Independent Monitor generally concurs with the overall findings of Section 4.14.2 of the AER (MRM, 2009a), which correlate with the flexibility shown in Section 6.1 of the MMP(MRM, 2008a) in managing, handling and classifying waste rock over time.

Contingencies for longer-term (>30 years) acid/saline leachate generation are not stated as a contingency in the MMP, although it is noted that in Section 6.1.1 of the MMP that lysimeters will be installed in the Overburden Emplacement Facility to monitor water infiltration, and it is assumed oxygen flux within pore spaces, which the Independent Monitor supports.

Following further evaluation of URS (2005) *Geochemical Assessment of Overburden and Tailings Material Including Conceptual Design of Overburden Emplacement Area* and discussion with the Senior Mine Geologist, Stephen Pevely (MRM), the Independent Monitor considers that the following geochemical classifications should be applied to waste rock:

- potentially acid forming (PAF) where % sulfur > 0.2% and net acid production potential (NAPP) > 0 kg sulphuric acid/tonne;

- non acid forming (NAF) where % sulfur is between 0% and 0.2% and NAPP < 0 kg sulphuric acid/tonne;
- uncertain (UC) where %sulfur > 2% and NAPP < 0 kg sulphuric acid/tonne;
- no sulfur (NS) where %sulfur < 0.2% and NAPP is between -30 and 0 kg sulphuric acid/tonne; and
- acid consuming (AC) where %sulfur < 0.2% and NAPP < -30 kg sulphuric acid/tonne.

Based on these categories, the Independent Monitor considers that the following waste rock strata can be classified as follows:

- upper pyritic shale – PAF/UC;
- lower pyritic shale – NAF/PAF/UC;
- bituminous shale – NAF/PAF/UC;
- lower dolomitic shale – NAF;
- W-Fold shale – mostly AC; and
- Teena dolomite – AC.

As indicated above, discussions with Stephen Pevely were initiated by the Independent Monitor to develop a greater understanding of the geological structural controls on both the ore mineralisation and in turn, the distribution of sulfides. Given the ore body, sulphide minerals in waste materials are likely to comprise of pyrite (FeS_2). Overall (particularly within the tailings) the dominant ratio of iron to sulphur is approximately 1:1, which (given the molecular weight of sulphur is around half that of iron) suggests that the dominant mineral present is pyrite.

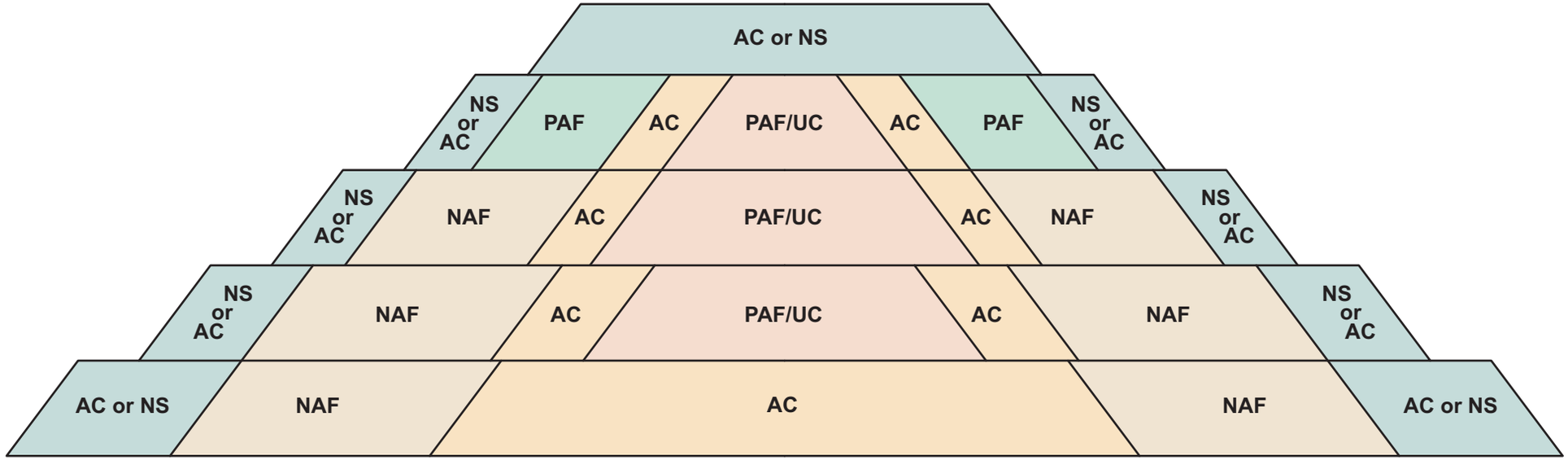
These discussions revealed that sulfides, as pyrite, are mostly disseminated throughout the pit, with only small amounts controlled by geological structures such as joints, vugs and dykes. Furthermore, it was revealed that the upper pyritic, lower pyritic and bituminous shales can be further separated into specific waste 'hazard classes' (i.e. NAF, PAF) in the pit based on their association with breccias. In brief, the occurrence of breccias with the shales can change the classification to UC or PAF as the sulfides are often associated with breccia.

The Independent Monitor commends the mine geologists for identifying the variations in waste geochemical classifications of materials generated as these measures will improve the environmental performance of MRM. However, this also highlights the need for MRM to update their current waste rock identification, handling and storage procedures as these changes need to be formalised should changes in mine personnel occur.

In its current form, the methods employed by the mine geologists in identifying and classifying waste rock vary from the adopted plan and as such, we recommend that the conceptual design, similar to that presented in Figure 16, and design be re-evaluated in conjunction with the field weathering trials described below. Furthermore MRM's written procedures need to be updated in line with the current practices undertaken, which includes and understanding of sulfide association with structure and geology.

Overburden Emplacement Facility waste geochemistry recommendations
The Independent Monitor provides the following recommendations for improving the environmental performance of the McArthur River Mine with respect to the monitoring and management of the geochemical characterisation of waste rock in the Overburden Emplacement Facility:

- larger scale field weathering trials be undertaken on selected materials that are currently classified as NAF, PAF, AC and UC to evaluate long-term leachate generation quality. As the rate of acid and/or saline leachate production, and possible change in geotechnical integrity, is function of the rock mineralogy, geochemistry and size, we consider that the results of kinetic column tests be abandoned or used in conjunction with larger scale field trials. These trials will also aid in the development of rehabilitation strategies;
- samples collected from both proposed and existing groundwater monitoring bores, as outlined in Section 6.2.2 of the MMP (MRM, 2008a), should be analysed on a quarterly basis for pH and total dissolved salts, cations (sodium, calcium, magnesium, potassium, ammonium), anions (chloride, bicarbonate (may be as calcium carbonate), sulfate, nitrate) and dissolved heavy metals (aluminium, arsenic, copper, iron, manganese, lead, zinc) in addition to field measurements of pH, electrolytic conductivity, redox potential, dissolved oxygen and temperature. This will, along with the development of a conceptual hydrogeological model for the Overburden Emplacement Facility area, will enable a pro-active approach in early identification of potential leachate breakthroughs and adverse impacts on groundwater and beneficial uses; and
- waste rock sorting, identification and sampling procedures should be updated to reflect current mining operations, including re-evaluation of the geochemical hazards classes and conceptual emplacement.



PAF (potentially acid forming) = >0.2% S^-, NAPP > 0 kg H_2SO_4/T

NAF (non-acid forming) = 0.2 - 2% S^-, NAPP < 0 kg H_2SO_4/T

UC (uncertain classification) = S^- > 2%, NAPP < 0 kg H_2SO_4/T

NS (no sulfur) = S^- <0.2%, 0>NAPP > -30 kg H_2SO_4/T

AC (acid consuming) = S^- <0.2%, NAPP < -30 kg H_2SO_4/T

ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

Title: **Conceptual Geochemical Classification of OEF**

Location: **McArthur River Mine Northern Territory**

Project: **McArthur River Mine Independent Monitor** | Job No: **209024**

Project Man: **GM** | Scale: **As shown** | **Figure 16**

Drawn By: **LB** | Date: **August 2009**

8.8.6 Bing Bong Port Dredge Spoil geotechnical monitoring

Site inspection

Members of the Independent Monitor team visually assessed the Bing Bong dredge spoil ponds during the June 2009 site inspection. Impacts by surface water and seepage into the adjoining land with likely impacts on flora and fauna raised within Section 7.1.2 and 8.6.3. The following discussion relates to civil and geotechnical considerations associated with the Bing Bong dredge spoil.

The Bing Bong dredge spoil area was briefly inspected as part of the June 2009 site inspection.

The following primary observations were made during the inspection:

- as documented within Plate 28 - Appendix E, the spoil pond embankments are in extremely poor condition with very deep rutting, erosion gullies, sinkholes, possibly animal warrens. MRM personnel reported this damage to have happened during the previous wet season;
- saline seepage from the dredge spoil has potentially caused tree die-back, with salt crystallisation observed across the surrounding tidal flats, stemming from the foot of the dredge spoil walls (see Plate 29 - Appendix E); and
- the primary drainage channel from the dredge spoil ponds to the Bing Bong Port had been blocked and was no longer in use as a drainage path way for saline seepage from the spoil ponds; and
- spoon drains at the outer foot of the spoil pond embankments are not connected and are therefore not functional.

McArthur River Mining confirmed that there is little to no technical documentation for the Bing Bong spoil dump. Before this facility is further used by MRM it should be reviewed and remediated as it is currently considered to be a failed asset.

The *Environmental Management Plan, Bing Bong Swing Basin 2008 Dredge Program* (MRM, 2008c:5) states a range of site preparation steps, which were to be undertaken prior to the dredging event due before 2008/2009 wet season. These preparation steps include:

- repair of walls and internal bunds, weir, pipes and culvert as required;
- construction of bunds to protect remnant (previously re-vegetated) vegetation where possible (however, it is unclear to the Independent Monitor where these re-vegetated areas are located); and
- repair/grading of drainage channel as required.

Whilst the Independent Monitor understands that the abovementioned dredging event had not gone ahead by the time of site inspection, it appears that the above preparation commitments have not been undertaken.

The Independent Monitor recommended to MRM during the site inspection that no further application of dredge material be added to the spoil piles until the integrity of the dredge bund walls had been investigated and walls rectified accordingly. The Independent Monitor understands that MRM is currently undertaking these works.

The Independent Monitor considers salt seepage from the dredge ponds on to the coastal flats to be a major issue of concern. As such, this issue was formally reported to MRM and

DRDPIFR in accordance with Section 6.4 of the Independent Monitor Assessment Conditions (IMACs) (see Section 7.1).

Geotechnical documentation review
All relevant documentation regarding design, construction and management for the spoil dump was requested to from MRM, however, the only document provided to the Independent Monitor was a brief email regarding a proposed trial (Kinna, 2008). It is therefore inferred that there is no design, construction control, monitoring or maintenance information is currently available for this facility. A geotechnical report was subsequently provided by MRM to the Independent Monitor, however was provided too late for inclusion within this report and will be review next audit. Environmental risks associated with the geotechnical integrity of the Bing Bong Dredge Spoil are provided within the risk analysis and gap analysis sections of this report (Sections 4 and 5).

Bing Bong dredge spoil geotechnical recommendations
The Independent Monitor provides the following recommendations regarding geotechnical issues at the Bing Bong Dredge Spoil:

- a review should be undertaken regarding the proposed future use of this facility, and an investigation and design program should be subsequently developed so that the existing structure can be remediated to a state where it can meet its objectives in accordance with generally acceptable industry standards; and
- following the above remediation, a management plan should be developed for continued operation including inspections, monitoring and usage strategies.

8.9 Other Matters

The Independent Monitor visually inspected the fuel storage facilities at Bing Bong, and suggest that a hydrocarbon audit and fuel line integrity testing be undertaken by MRM.

9 CONCLUSIONS AND RECOMMENDATIONS

The Independent Monitor of the McArthur River Mine has undertaken an audit of the environmental performance of the operation based on the period from October 2007 to September 2008 (“the 2008 Operational Period”). This review period is in-line with the operational mine management plan (MMP) for the period (MRM, 2008a), whilst the annual environment report (AER) (MRM, 2009a) covers the period of 2005 to 2008.

The audit for the 2008 Operational Period comprised an assessment of the Mine’s environmental performance, which was assess through:

- site inspections and interviews with personnel ;
- undertaking of a risk assessment and gap analysis;
- undertaking a review of environmental assessments and audits undertaken by DRDPIFR in undertaking their check monitoring of MRM;
- undertaking a compliance review of MRM systems and procedures against statutory commitments;
- undertaking a technical audit of the environmental monitoring undertaken by MRM with regard to the following significant focus areas:

  - surface water and artificial surface waters (including potable water);
  - groundwater;
  - fluvial sediments;
  - dust and soils;
  - marine seawater, sediments and dredging;
  - flora and fauna;
  - the McArthur River and Barney Creek diversions;
  - the Bing Bong dredge spoil ponds; and
  - civil works such as the overburden emplacement facility, Tailings Storage Facility stability, and overall geotechnical evaluations of the diversions; and
- the provision of recommendations for further studies, investigations and management strategies designed to improve the environmental performance of the Mine operation.

The risk assessment and gap analysis identified several gaps primarily relating to the monitoring and reporting of the diversion works; geochemical characterisation of waste rock; geotechnical and seepage impacts at the Bing Bong dredge spoil ponds; geotechnical and monitoring issues of the Tailings Storage Facility; monitoring and management of mosquitoes; and warning of extreme flood events.

Recommendations for 'closing' these gaps have been provided, and many of these related to key issues identified in the 2006-2007 Independent Monitor report. It should be noted that the reporting, presentation and interpretation of monitoring in the 2005-2008 AER (MRM, 2009a) has improved substantially compared to the 2006-2007 review period AER.

The systems and procedures audit of MRM a generally high level of compliance with their commitments, although three non-conformances were observed. These related to the accelerated salt leaching and landform stabilisation of the Bing Bong dredge spoil ponds, inadequate verification of the Overburden Emplacement Facility clay liner, and the mosquito monitoring and management programs. It is acknowledged that MRM have provided documented commitments that these non-conformances will be addressed in 2009. Recommendations for addressing the observations relate to the same areas highlighted in the gap analysis.

Based on the technical audit of the aforementioned study areas, i.e. groundwater, diversion works, etc, the Independent Monitor has provided recommendations for improving the environmental performance of the MRM operation. These recommendations are provided within relevant sections throughout the report. Primary recommendations include, (but are not limited to):

- ensuring that all monitoring commitments are adhered to, including the monitoring frequency and analytes;
- ensuring that all figures provided in future monitoring and assessment reports prepared by MRM feature all current relevant monitoring points, including seepage abstraction bores near the Tailings Storage Facility;
- enhance the technical interpretation of the spatial and temporal trends of data sets across all areas of study. This also relates to the provision of "as-built" construction reports for the diversion works and overburden emplacement facility;

- improve the rehabilitation works and management, including maintaining adequate fencing to keep livestock and feral animals off the sites;
- update the geochemical and geotechnical testing and documentation procedures to reflect the changes in geochemical characterisation and current impacts at the Tailings Storage Facility; and
- undertake immediate and medium-term studies and rectification works at the Mine site (regarding weed management), the Bing Bong load-out facility and the Tailings Storage Facility.

From the information provided within this audit report, the following issues are considered to require urgent investigation:

- seepage and structural integrity of the Bing Bong dredge spoil ponds; and
- seepage migration from the Tailings Storage Facility to Surprise Creek and the hazard classification of tailings in Cell 1 and Cell 2.

Although not urgent, the following issues are considered significant and require corrective action to improve MRM's environmental performance:

- fugitive dust emissions at the Bing Bong load-out facility; and
- weed management along river diversion channels and the mine site.

Minor issues that are considered to require medium-term rectification relate to:

- the generation of dust from the Run of Mine Pad towards Barney Creek and its tributary;
- the design and potential recurrence of failure of the drain sump at the base of the Run of Mine Pad;
- the poor condition of asphalted and paved surfaces at the Bing Bong load-out facility;
- inadequate analysis of the accuracy, reproducibility and precision of routine monitoring results collected by MRM. This includes checking field measurements against laboratory results and expected objectives, and using a data quality sign-off sheet for quality assurance;
- rapid maintenance of fencing (damaged by annual floods) to improve rehabilitation works; and
- in-place testing of the clay liner of the Overburden Emplacement Facility as part of future Overburden Emplacement Facility expansions.

10 LIMITATIONS

This report has been prepared by Environmental Earth Sciences VIC ABN 13 109 404 024 in response to and subject to the following limitations:

1. The Independent Monitor Assessment Conditions (IMACs);
2. The specific scope of services set out in contract issued by DRDPIFR – Document KO7-0065;

3. May not be relied upon by any third party not named in this report for any purpose except with the prior written consent of Environmental Earth Sciences VIC (which consent may or may not be given at the discretion of Environmental Earth Sciences VIC);
4. This report comprises the formal report, documentation sections, tables, figures and appendices as referred to in the index to this report and must not be released to any third party or copied in part without all the material included in this report for any reason;
5. The report only relates to the site referred to in the scope of works being the McArthur River Mine and Bing Bong Port facilities, Northern Territory ("the site");
6. The report relates to the site as at the date of the report as conditions may change thereafter due to natural processes and/or site activities;
7. No warranty or guarantee is made in regard to any other use than as specified in the scope of works and only applies to the depth tested and reported in this report; and
8. Our General Limitations set out at the back of the body of this report.

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12 GLOSSARY OF TERMS

The following descriptions are of terms used in the text of this report.

Abiotic not involving biological activity.

Abrupt boundary boundary is less than 2 cm wide.

Acid neutralising capacity (ANC) the soils natural resistance to acid generation. It is the number of moles of protons per unit mass of soil required to raise the pH of the soil by one pH unit. ANC is measured as percentage $CaCO_3$.

Acidify addition of acid to lower pH.

Adsorption attraction and binding of solutes from an (usually) aqueous solution to surfaces of solid or colloidal particles with which it is in contact.

Aeolian deposition of unconsolidated wind blown soil material.

Alluvial describes material deposited by, or in transit in, flowing water.

Anaerobic reducing or without oxygen.

Anoxic sediments, soil and waters in which the dissolved oxygen concentration approaches zero.

Apedal describes a soil in which none of the soil material occurs in the form of peds or soil aggregates in the moist state.

Apedal massive soil occurs as a coherent mass with no distinct arrangement of soil particles.

Aquifer rock or sediment in a formation, group of formations, or part of a formation which is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.

Aquifer, confined aquifer that is overlain by a confining bed with significantly lower hydraulic conductivity than the aquifer.

Aquifer, perched region in the unsaturated zone where the soil is locally saturated because it overlies soil or rock of low permeability.

Aquitard a unit of low-permeability that can store groundwater and also transmit it slowly.

Background natural level of a property.

Baseline initial value of a measure.

Borehole an uncased well drill hole.

Buffer ionic compound, usually a salt of a weak acid or base~~,~~ added to a solution to resist changes in its acidity or alkalinity and thus stabilise its pH.

Capillary Fringe zone immediately above the water table, upward into which water is drawn by capillary forces.

Cation Exchange Capacity (CEC) maximum positive charge required to balance the negative charge on colloids (clays and other charged particles). The units are milli-equivalents per 100 grams of material or centimoles of charge per kilogram of exchanger.

Clay Soil material composed of particles finer than 0.002 mm. When used as a soil texture group such soils contain at least 35% clay.

Claystone sedimentary rock composed primarily of clay sized particles.

Colluvial unconsolidated soil and rock material moved down-slope by gravity.

Conductivity (EC) conductivity of water is an expression of its ability to conduct an electric current. This property is related to the ionic content of the sample, which is in turn a function of the total dissolved (ionisable) solids (TDS) concentration. An estimate of TDS in fresh water can be obtained by multiplying EC by 0.65.

Confined Aquifer an aquifer whose upper and/or lower boundaries are confined by an almost impermeable geological formation, e.g. a clay layer. The water in these aquifers is usually under hydraulic pressure, e.g. artesian or sub-artesian conditions.

Confining layer an aquitard or sparingly permeable layer that confines the limits of an aquifer.

Contaminant generally, any chemical species introduced into the soil or water. More particularly relates to those species that render soil or water unfit for beneficial use.

Contamination is considered to have occurred when the concentration of a specific element or compound is established as being greater than the normally expected (or actually quantified) background concentration.

Diffusion process by which species in solution move, driven by concentration gradients (from high to low).

Dilution the mixing of a small volume of contaminated leachate with a large volume of uncontaminated water. The concentration of contaminants is reduced by the volume of the lower concentrated water. However the physical process of dilution often causes chemical disequilibria resulting in the destruction of ligand bonds, the alteration of solubility products and the alteration of water pH. This usually causes precipitation by different chemical means of various species.

Discrete sample samples collected from different locations and depths that will not be composited but analysed individually.

Dispersion process by which species in solution mix with a second solution, thus reducing in concentration. In particular, relates to the reduction in concentration resulting from the movement of flowing groundwater.

Dissolved Oxygen (DO) oxygen in the gaseous phase dissolved in water. Measured either as a concentration in mg/L or as a percentage of the theoretical saturation point, which is inversely related to temperature. At 19, 20 and 21 degrees Celsius, the oxygen concentrations in mg/L corresponding to 100% saturation are 9.4, 9.2 and 9.0 respectively.

Drawdown lowering of a water table by pumping from one or more wells.

Electrolytic conductivity (EC) measure of the extent to which water conducts an electrical current and is related to the total concentration and relative proportions of the dissolved ionised substances within the water, and the temperature at which the determination is made.

Ephemeral stream a stream that flows only during periods of precipitation and briefly thereafter, or during periods of elevated water-table levels when the stream is in direct hydraulic connection with the underlying unconfined aquifer (i.e. receives base-flow).

Flow path direction in which groundwater is moving.

Fluvial material deposited by, or in transit, in streams or watercourses.

Fracture break in the geological formation, e.g. a shear or a fault.

Gradational lower boundary between soil layers (horizons) has a gradual transition to the next layer. The solum (soil horizon) becomes gradually more clayey with depth.

Gradient rate of inclination of a slope. The degree of deviation from the horizontal; also refers to pressure.

Groundwater water held in the pores of an aquifer.

Gully erosion displacement of soil by running water that forms clearly defined, narrow channels that generally carry water only during or after heavy rain.

Hydraulic Head. The sum of the head's (potentials) at a point in an aquifer.

Heavy Metals all metallic elements whose atomic mass exceeds that of calcium (20) and includes lead (Pb), copper (Cu), Zinc (Zn), cadmium (Cd), and tin (Sn).

Humic/Humus referring to organic matter within soil.

Hydraulic conductivity rate of water movement through soil.

Hydraulic continuity water bridge or connection between two or more geological formations.

Hydrocarbon molecule consisting of carbon and hydrogen atoms only, such as found in petroleum.

Hydrocarbon, volatile a hydrocarbon with a low boiling point (high vapour pressure). Normally taken to mean those with ten (or less) carbon atoms per molecule.

Infiltration passage of water, under the influence of gravity, from the land surface into the subsurface.

Injection well groundwater bore constructed for the purpose of pumping water into an aquifer.

Ionic Exchange adsorption occurs when a particle with a charge imbalance, neutralises this charge by the attraction (and subsequent adherence of) ions of opposite charge from solution. There are two types of such a charge: pH dependent; and pH independent or crystalline charge. Metal hydroxides and oxy-hydroxides represent examples of the former type, whilst clay minerals are representative of the latter and are normally associated with cation exchange.

Ions an ion is a charged element or compound as a result of an excess or deficit of electrons. Positively charged ions are called cations, whilst negatively charged ions are

called anions. Cations are written with superscript +, whilst anions use - as the superscript. The major aqueous ions are those that dominate total dissolved solids (TDS). These ions include: Cl^-, SO_4^{2-}, HCO_3^-, Na^+, Ca^{2+}, Mg^{2+}, K^+, NH_4^+, NO_3^-, NO_2^-, F^-, PO_4^{3-} and the heavy metals.

Leachate water that flows through waste material (or other material) will liberate soluble molecules to form leachate.

Micro-organism Literally "small organisms" because they usually cannot be observed without magnification. Includes viruses, bacteria, yeasts and fungi, and others.

Mottled masses, blobs or blotches of sub-dominant, varying colours in the soil matrix.

Net acid generation potential (NAGP) difference between the TOS and ANC reported on a kilogram H_2SO_4 production per tonne of soil.

Nitrogenous compounds most nitrogen occurs as a gas (N_2) in the atmosphere. Nitrogen compounds are transformed by biological processes. In the presence of oxygen, organically bound nitrogen is oxidised: ammonium (NH_4^+) to nitrate (NO_2^+) to nitrate (NO_3^-). However in the leachate from refuse tips the oxygen demand is great, as expressed by high COD and as a result nitrogen compounds are reduced, i.e. the reverse of oxidation.

Organics chemical compounds comprising atoms of carbon, hydrogen and others (commonly oxygen, nitrogen, phosphorous, sulfur). Opposite is inorganic, referring to chemical species not containing carbon.

Oxidation originally referred only to the addition of oxygen to elements. However oxidation now encompasses the broader concept of the loss of electrons by electron transfer to other ions.

Oxygen demand all fresh water contains dissolved oxygen at a concentration between 8 to 10 mg/L. Micro-organisms consume oxygen in utilising organic waste as food while producing CO_2 and H_2O. Therefore, an excess of organic material can reduce dissolved oxygen levels to zero because the rate of dissolved oxygen consumption is far greater than its rate of replenishment. This capability of organic material to consume oxygen in water is called biological or biochemical oxygen demand (BOD).

Parameters population value of a particular characteristic, which is descriptive of the distribution of a random variable.

Perched Aquifer (or water table) a body of water located above an impermeable geological formation. These perched aquifers (or water tables) are nearly always seasonal or periodic.

Permeability property of porous medium relating to its ability to transmit or conduct liquid (usually water) under the influence of a driving force. Also refereed to as hydraulic conductivity.

Piezometer a cased borehole with a short slotted screen for measuring standing water level (SWL), which represents a potentiometric surface or elevation of the water table; also used to obtain sample of groundwater for quality assessment.

pH logarithmic index for the concentration of hydrogen ions in an aqueous solution, which is used as a measure of acidity.

Plume spreading of a contaminant from a point source, under the influence of dispersion, diffusion and the like.

Potentiometric Surface water level that represents the standing or total hydraulic standing head. In an aquifer system it represents the levels to which water will rise in tightly cased walls (e.g. a cased borehole).

Precipitation (chemical) there are two types of precipitation, pH dependent precipitation and solubility controlled precipitation. As the pH is raised beyond a threshold level the precipitation of metal cations such as oxy-hydroxides and hydroxides occur. As the pH is raised further precipitation continues until there are very few metal cations remaining in solution. This reaction is entirely reversible. Solubility controlled precipitation occurs between two ions when, at a given temperature and pressure, the concentration of one of the ions exceeds a certain level.

Profile the solum. This includes the soil A and B horizons and is basically the depth of soil to weathered rock.

Purge (wells) pumping out well water to remove drilling debris or impurities; also conducted to bring fresh groundwater into the casing for sample collection. The later ensures that a more representative sample of an aquifer is taken.

QA/QC Quality Assurance / Quality Control.

Recharge Area location of the replenishment of an aquifer by a natural process such as addition of water at the ground surface, or by an artificial system such as addition through a well

Recovery rate at which a water level in a well rises after pumping ceases.

Redox REDuction-OXidation state of a chemical or solution.

Redox potential (Eh) oxidation/reduction potential of the soil or water measured as millivolt.

Reducing Conditions can be simply expressed as the absence of oxygen, though chemically the meaning is more complex. For more details refer to OXIDATION.

Remediation restoration of land or groundwater contaminated by pollutants, to a state suitable for other, beneficial uses.

Representative Sample assumed not to be significantly different than the population of samples available. In many investigations samples are often collected to represent the worst case situation.

Saturated Zone zone in which the rock or soil pores are filled (saturated) with water.

Sheet erosion removal of surface material from a wide area of gently sloping or graded land by broad continuous sheets of running water rather than by streams.

Siderite carbonate form of iron (Fe^{2+}), chemical composition $FeCO_3$. Commonly found in presence of sideroplesite ($MgCO_3$) within carbonaceous rocks, or as precipitation from carbonaceous groundwater.

Slate fine grained metamorphic rock derived mostly from shale. Characterised by the ability to spilt into large thin flat sheets.

Sodic term given to soil with a level of exchangeable sodium cations greater than 10-15% of the soils cation exchange capacity (CEC), or soluble sodium cations greater than 10-15 times the square root of soluble calcium and magnesium cations. These terms are known as exchangeable sodium percentage (ESP) and sodium adsorption ratio (SAR) respectively.

Solod/Solodic soil with strong gradational texture contrast between mildly leached, slightly alkaline loamy pale topsoil and alkaline clay subsoil with coarse blocky or columnar structure. Have bleached A_2 horizons and alkaline B and C horizons.

Soloths soils which are acidic throughout the solum and have a strong textural boundary between the pale topsoil and the clay subsoil with coarse blocky or columnar structure

SPT Standard Penetration Test. Common drill method used to calculate the relative density and consistency of material.

Stolonated above ground root system allowing vertical spread of grass species such as kikuyu and couch.

Storativity volume of water stored or released by an aquifer per unit volume (of porous medium) per unit change in head.

Stratigraphy vertical sequence of geological units.

Subsidence the downward settling of material with little horizontal movement.

Subsoil subsurface material comprising the B and C horizons of soils with distinct profiles. They often have brighter colours and higher clay content than topsoils.

Suspended Solids (SS) matter which is suspended in water which will not pass through a 0.45 µm filter membrane.

Texture is the size of particles in the soil. Texture is divided into six groups, depending on the amount of coarse sand, fine sand, silt and clay in the soil.

Topsoil part of the soil profile, typically the A1 horizon, containing material which is usually darker, more fertile and better structured than the underlying layers.

Total Acidity (TA) difference between the soil CEC and ANC.

Total Actual Acidity (TAA) moles of titratable protons per unit mass of soil displaced by an un-buffered KCl solution, otherwise known as the salt-replaceable acidity.
Total Dissolved Salts (TDS) total dissolved salts comprise dissociated compounds and undissociated compounds, but not suspended material, colloids or dissolved gases.

Total Organic Carbon (TOC) measure of the total organic carbon within a water sample. It is complementary to the oxygen demand analyses and theoretically independent of the form in the carbon exists.

Total Oxidisable Sulfur (TOS) maximum oxidisable sulfur present and represents the maximum production of acid possible from sulfide oxidation.

Toxicity the inherent potential or capacity of a material to cause adverse effects in a living organism.

Transmissivity rate at which water is transmitted through a unit width aquifer under a unit hydraulic gradient.

Turbidity describes the degree of opaqueness produced in water by suspended particulate matter.

Unsaturated zone vadose zone. The zone between the land surface and the water table, in which the rock or soil pores contain both air and water.

Vadose zone zone containing water under pressure less than that of the atmosphere, including soil water, intermediate vadose water, and capillary water. This zone is limited above by the land surface and below by the surface of the zone of saturation, that is the water table.

Water table interface between the saturated zone and unsaturated zones. The surface in an aquifer at which pore water pressure is equal to atmospheric pressure.

ENVIRONMENTAL EARTH SCIENCES GENERAL LIMITATIONS

Scope of services

The work presented in this report is Environmental Earth Sciences response to the specific scope of works requested by, planned with and approved by the client. It cannot be relied on by any other third party for any purpose except with our prior written consent. However, any party wishing to rely on this report should contact us to determine the suitability of this report for their specific purpose.

Data should not be separated from the report

A report is provided inclusive of all documentation sections, limitations, tables, figures and appendices and should not be provided or copied in part without all supporting documentation for any reason, because misinterpretation may occur.

Subsurface conditions change

Understanding an environmental study will reduce exposure to the risk of the presence of an environmental hazard. However, hazards may be present in areas that were not investigated, or may migrate to other areas. Monitoring cannot cover every type of hazard that could possibly be present. When combined with field observations, field measurements and professional judgement, this approach increases the probability of identifying hazards. Under no circumstances can it be considered that these findings represent the actual condition of the site at all points.

Environmental studies identify actual site conditions only at those points where samples are taken, when they are taken. Actual conditions between sampling locations differ from those inferred because no professional, no matter how qualified, and no sub-surface exploration program, no matter how comprehensive, can reveal what is hidden below the ground surface. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not sampled may differ from that predicted. Nothing can be done to prevent the unanticipated. However, steps can be taken to help minimize the impact. For this reason, site owners should retain the services of competent environmental assessors.

Problems with interpretation by others

Advice and interpretation is provided on the basis that subsequent audit will be undertaken by Environmental Earth Sciences. We cannot be responsible for how the information in this report is used. If further data is collected or comes to light we reserve the right to alter their conclusions.

Obtain regulatory approval

The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a project, that approval should be directly sought by the client.

Limit of liability

This study has been carried out to a particular scope of works at a specified site and should not be used for any other purpose. This report is provided on the condition that Environmental Earth Sciences VIC disclaims all liability to any person or entity other than the client in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by any such person in reliance, whether in whole or in part, on the contents of this report. Furthermore, Environmental Earth Sciences VIC disclaims all liability in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by the client, or any such person in reliance, whether in whole or any part of the contents of this report of all matters not stated in the brief outlined in Environmental Earth Sciences VIC's proposal number and according to Environmental Earth Sciences general terms and conditions and special terms and conditions for contaminated sites.

To the maximum extent permitted by law, we exclude all liability of whatever nature, whether in contract, tort or otherwise, for the acts, omissions or default, whether negligent or otherwise for any loss or damage whatsoever that may arise in any way in connection with the supply of services. Under circumstances where liability cannot be excluded, such liability is limited to the value of the purchased service.

APPENDIX A RISK MATRIX AND RISK RATING EXPLANATION

RISK MATRIX

Consequence		Likelihood (regardless of potential time latency)				
		1	2	3	4	5
		Certain	Likely	Possible	Unlikely	Improbable
1	Catastrophic	2	3	4	5	6
2	Major	3	4	5	6	7
3	Moderate	4	5	6	7	8
4	Minor	5	6	7	8	9
5	Insignificant	6	7	8	9	10

RISK RATING EXPLANATIONS

Risk Matrix result	Risk Rating	Description
2 to 3	E	**Extreme-** Immediate intervention required to eliminate or reduce risk at a Senior Management/ Government level.
4 to 5	H	**High Risk -** It is essential to eliminate or reduce risk to a lower level by the introduction of monitoring and assessment measures implemented by senior management.
6 to 7	M	**Moderate -** Corrective action required, and monitoring and assessment responsibilities must be delegated.
8 to 10	L	**Low Risk -** Corrective action should be implemented where practicable, and risk should be managed by routine monitoring and assessment procedures.

KEY TO RISK RATING TABLE

Location of impact	
RI	Regional impact (>2km radius outside mining lease)
OM	Impact outside mine lease area - (<2km radius)
WM	Wide impact within mining lease boundaries
L	Localised area within mining lease boundaries
P	Small point source within mining lease boundary
Potential Duration of impact	
G	Geological long term (>100 years)
L	Long term (30- 100)
M	Medium term (5-30 years)
S	Short term (1-5 years)
E	Ephemeral/seasonal impact

APPENDIX B RISK REGISTER

ENVIRONMENTAL RISK REGISTER (PRESENTED IN RISK RANK ORDER)

Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
Geochemical	Bing Bong dredge spoil dams	Migration of saline/ hypersaline seepage causing local and regional vegetation die-back.	M	RI	Drainage and seepage occurring into adjacent land due to seepage through wall , and blockage of drain to sea.	None	2	1	**3**	E	Survey land, Create outer spoon drain to redirect saline seepage back to sea. Drain to sea re-established. Monitor re-growth in areas around spoil piles for signs of stress and dieback.
Geotechnical	Bing Bong dredge spoil dams	Catastrophic failure of dam walls leading to increased salt seepage into adjacent areas.	M	OM	Failure of walls due to Poor construction of spoil dump embankments / cells.	Infrequent inspections undertaken by Bing Bong staff. Commitment to undertake rehabilitation trials.	2	1	**3**	E	Spoil dump needs to be investigated and remediated (new design / new construction) as it is not currently performing its intended function (i.e. vegetation downstream of embankment was stressed, stunted or dead). This should be an area of focus in a 'Comprehensive Dam Inspection' and 'Dam Safety Review'. Depending on the findings of both assessments, remedial works may be required. In the interim, this should be an area of focus for regular inspections (unclear from provided inspection proformas, how often the area is visited).

Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
Geochemical	OEF	Reduced stability of structure and generation of acidic and/or saline leachate	G	RI	NAF material may be acid-forming and therefore incorrectly placed.	Reports show very high sulfide is present with excess ANC. Structural association of sufides in waste rock not entirely understood.	1	2	**3**	E	Evidence has been provided of procedures and checks for 2009 which suggest that active grading/ monitoring is currently occurring. Grading by mine geologist is substantially more detailed than that undertaken in accordance with relevant wast rock planning/ procedures documents. Procedures need to be updated in line with this practice. Lysimeter trials "at life size" need to be considered to evaluate fate of high Sulfate NAF.
Geochemical	Tailings Dam Cell 1	Discharge of seepage containing salt, acid, and metals enters Surprise Creek	L	RI	Acid-producing tailings not expected, Lack of TSF liner. Close location of TSF Cell 1 to Surprise Creek.	Seepage recovery bores Shallow Cut-off barrier Monitoring of surface water and groundwater and incoming tailings	2	2	**4**	H	Ascertain velocity of groundwater (and acid and dissolved metals). Establish long-term oxidation rate of tailings Response to monitoring results of current tailings.
Dust Monitoring	Dust from Mine site operations	Contamination of surface soils, vegetation, sediment with salts, heavy metals	L	L	Spread of zinc and lead laden dust from mining operations	Dust monitoring program and dust mitigation measures	3	1	**4**	H	Activities from ROM pad/Pacrim yard resulting in elevated lead and zinc dust levels. Dust monitoring results show that TSF is generating significant dust at D15. Dust mitigation measures should be increased around ROM Pad/Pacrim yard. Rehabilitation of TSF Cell 1 should improve dust levels at D15 however dusting of TSF should be regularly monitored.

Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
Dust Monitoring	Dust from Bing Bong Port facilities	Contamination of marine and terrestrial environment with metals.	L	L	Spread of zinc and lead laden dust from ship-loading operations.	Dust monitoring programme and dust mitigation measures	3	1	**4**	H	Bing Bong Port shows consistently higher lead and zinc dust levels in 07/08 period compared with previous reporting year. Further investigation into increased dust levels at Bing Bong should be undertaken.
Flora	Weed Management	Increase in spread of listed Northern Territory noxious weed species, particularly along the River Diversions.	S	RI	Historical mining and pastoral activities. Uncolonised bank and bed of river diversions. Weed Management Plan implemented during shutdown (Dec 2008-Feb2009)	Weed Management Plan in place.	3	1	**4**	H	Implementation of existing Weed Management Plan needs to be augmented with other activities to compensate for shutdown. Invest more resources to accelerate revegetation and weed control (MRM have expressed an intent to do this prior to the 2009/2010 wet season).
Flora	Surprise Creek	Seepage from TSF causes flora die back and/ or bioaccumulation of metals in flora.	S	L	Seepage from TSF into surprise creek.	TSF geopolymer barrier; TSF design; Seepage monitoring.	3	1	**4**	H	Undertake further investigation into TSF seepage monitoring and mitigation; undertake periodic visual inspections of Surprise Creek and surrounds to monitor and assess flora health. Flora dieback is currently observed to be occurring.

Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
Fauna	Wallaby populations at Bing Bong reserve	Loss of habitat and increased human traffic/presence.	L	OM	Seepage from Dredge Ponds spreading over tidal flats resulting in die-back of native vegetation cover. Human presence and traffic from Bing Bong operations.	None known.	2	2	**4**	H	Correct dredge spoil seepage and drainage management. Survey and monitor vegetation regrowth and monitor seepage.
Geotechnical	OEF	Water infiltrates into OEF PAF cells and degrades integrity of structure.	M	OM	Poor construction of PAF cells, foundation, poor quality control over placement of clay lining. Poor construction of OEF cap.	No specific monitoring or testing - relying on testing done from stockpile of material used for bund and channel construction (this has not been provided). It does not matter as permeability is a function of material properties, compaction and moisture content. This has to be confirmed at point of placement	2	3	**5**	H	All future cell linings should be quality control tested. For completed cells, if possible, retrospective testing should be undertaken (unlikely to be possible, unless drill through existing cells). It is noted in the URS test results that the permeability results for the in-situ soils are <1x10-9 m/sec.

Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
Geotechnical	TSF Cell 1	Cell 1 embankment fails, spillage into Surprise Creek	M	WM	Poor Design, construction, maintenance; Significant Storm Event, Seismic Event etc	Daily MRM visual inspections, Allan Watson Associates annual inspections, Monitoring from recovery wells d/s of embankment.	1	4	**5**	H	In the absence of design and construction information, and given the evidence of contaminant migration, in keeping with ANCOLD requirements (which AWA say they are complying with) a comprehensive inspection, Dam Safety Review) and possible remedial works are required. The IM agrees with AWA's recommendation in 2008 annual inspection that water level monitoring from within the embankment should be established so that ongoing stability can be checked. Although only a trial at this stage, if the clay capping for Cell 1 is to be relied upon as a measure to prevent water infiltration, there must be more strict quality control over material selection and placement of the clay cap. It is noted that several of the management strategies proposed for Cell 1 in the 2007-2008 MMP for 2008 had not been actioned by the time of the site inspection in 2009.

Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
Geotechnical	TSF Cell 2	Cell 2 embankment fails	M	WM	Poor Design, Poor Construction, Poor Maintenance, Significant Storm Event, Seismic Event etc	Daily MRM visual inspections, AWA annual inspections, Monitoring from recovery wells d/s of embankment.	1	4	**5**	H	The independent monitor group has not been provided with a copy of the Cell 2 design report, therefore it is not possible to comment on whether construction and subsequent operation are in accordance with the design intent (or if the design approach is satisfactory). This review needs to be completed. The IM recommends that Cell 2 be included within the scope of the 'Comprehensive Inspection' and 'Dam Safety Review', which should be conducted for Cell 1 and the Water Management Dam.
Fauna	Fish in Barney Creek & McArthur River diversions	Decrease in population of freshwater sawfish	M	L	Loss of habitat, reduction in water quality	Freshwater Sawfish Monitoring and Management Programme in place	2	3	**5**	H	Additional habitat enhancement and increased revegetation of the diversion channel is required based on erosion impacts occurring in the 2008 wet season. The amount of 'snags' to the diversion. This will increase fish habitat,
Fauna	Surprise Creek	Seepage from TSF causes loss of fauna, or bioaccumulation of metals fauna.	S	L	Seepage from TSF into surprise creek.	TSF geopolymer barrier; TSF design; Seepage monitoring.	3	2	**5**	H	Undertake further investigation into TSF seepage monitoring and mitigation; undertake periodic visual inspections of Surprise Creek and surrounds to monitor and the presence of fauna.

Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
Geotechnical	OEF	OEF wall fails and falls into McArthur River	M	WM	Abnormal storm event, poor construction	Visual inspections of wall condition (to check)	1	4	**5**	H	"As-built" construction reports of final structure.
Groundwater	Mine site and TSF	Degradation of groundwater, surface water and land quality within the mine site and the TSF	M	WM	Long- and short-term generation of acidic and/or saline leachate from tailings and waste rock	Groundwater, surface water, tailings and waste rock monitoring, checking procedures, kinetic testing of materials with uncertain classification, TSF annual inspections	2	3	**5**	H	Increased monitoring and modification of the analytical regime for groundwaters and interstitial water in and around the TSF; modifications to the kinetic testing of tailings and waste rock sorting procedure; more rigorous annual reporting and modelling of groundwater.
River diversions	Barney Creek & McArthur River diversions	Difficulty in establishing desired vegetation corridor.	S	L	Flood-time loss of soil	Plot surveys of plant densities after twelve months and longer time frames	3	2	**5**	H	Confirmation that the plot surveys will be adequate to assess this issue
Geotechnical	TSF Cell 1	Over-flow of Cell 1 due to overtopping of spillway	M	OM	Under-designed for Flood event	Identified in AWA 2008 annual inspection that it is unclear if the spillway has been adequately designed. OPSIM modelling undertaken annually.	3	3	**6**	M	AWA has identified that the spillway for Cell 1 is possibly undersized. A comprehensive inspection and Dam Safety Review would include covering this issue, and should integrate the findings of the OPSIM modelling.

Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
Geotechnical	Water management dam.	Failure due to overtopping of spillway	M	OM	Under-design for potential Flood	None. The IM notes that AWA 2008 annual inspection identifies that it is unclear if the spillway has been adequately designed.	3	3	**6**	M	AWA has identified that the spillway for the WMD is possibly undersized - given that the TSF flood management strategy has this spillway as critical component this design issue should be resolved as a high priority. A comprehensive inspection and Dam Safety Review would include this issue.
Geotechnical	ROM Pad	Erosion of bund wall causes release of contaminated water into Barney Creek	S	L	Abnormal storm event	Regular inspections of condition	4	2	**6**	M	Complete quantified design of water flows (determine likely volumes), and design spillway (protected low point) to prevent total loss of bund / road and release of large volume of contaminated material and to prevent Barney Creek scouring out bund.
Marine sediments	Sediment quality at Bing Bong Port and Sir Edward Pellew Islands	Bing Bong Port and Mine operations cause heavy metal contamination of marine sediments, which may affect flora and fauna.	M	L	Dust / spills from ship-loading operations, and dust from Mine entering the McArthur River	Dust management measures, stockpile control measures, and ship loading procedures.	3	3	**6**	M	Continued dredging of swing basin to remove localised contaminated sediment. Further investigation should occur regarding why mine-sourced lead and other metal concentrations have been found to increase in marine sediment at Bing Bong since 2004 and the McArthur River Delta since 2007.

Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
Bing Bong Surface Runoff Pond (BBSRP)	Bing Bong Port	Overflow of BBSRP contaminates surrounding environment	S	L	High-rainfall storm event, or failure to clean out sediment from pond	BBSRP maintenance programme, annual OPSIM modelling undertaken, evaporation of pond water through use of pond water as dust suppression across site.	3	3	**6**	M	During the IM's site inspection in December 2008, the BBSRP appeared to have insufficient freeboard to withstand the pending wet season. There appeared to be a large amount of sediment in the pond to be cleaned out to improve capacity and improve water quality for reuse. BBSRP should be cleaned out on a regular basis and emptied as far as practicable prior to the wet season.
Fauna	Birds -McArthur River riparian woodland habitat corridor	Loss of woodland to open forest corridor	M	WM	Loss of habitat, reduction in water quality	Seasonal monitoring of riparian birds using colour banding	3	3	**6**	M	Implementation of riparian bird monitoring programme satisfactory
Fauna	Birds - Barney Creek & McArthur River diversions	Loss of native cane grass habitat for riparian birdlife	M	WM	Loss of habitat, changes to bird species distribution	Riparian Bird Monitoring Programme	3	3	**6**	M	Management of fencing to keep cattle and donkeys out of rehabilitated areas
Fauna	Migratory Birds -Bing Bong Port	Impacts to migratory birds	L	P	Metal contamination of sediment impacting food sources for migratory bird habitat	Monitoring of metal contamination in sediment in potential habitat for migratory birds	3	3	**6**	M	Reduce dust emissions from Bing Bong Port operations.

Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
Flora/fauna	Surprise Creek	Dust contamination of Surprise creek causes loss of flora/ fauna or bioaccumulation of metals within tissues.	M	WM	Dust blown from TSF.	Surface water monitoring programme; dust control measures (clay cap and watering) at TSF surface.	3	3	**6**	M	Complete rehabilitation and clay cover of TSF.
Flora/fauna	Barney Creek / McArthur River	Dust blown from mining operations causes loss of water quality and loss of flora/ fauna in Barney creek and McArthur River.	M	L	Fugitive dust emissions from mining operations.	Dust mitigation measures at mine site including Water spray trucks etc.	3	3	**6**	M	Assessment of contamination trends difficult due to limited data set. Increase in sulphate levels should be closely monitored.
Geotechnical	TSF Pipeline Over River	Pipeline foundations fail, rupturing pipe resulting in discharge of tails into Barney Creek	S	L	Flood event undermines footings	Daily monitoring during wet season to inspect pipeline integrity.	2	4	**6**	M	Regular monitoring should identify any gradual deterioration of footings before it has potential to damage pipeline. It is understood that a bund is to be constructed around the pipeline on the TSF abutment to contain any leaks over the crossing and this should also contain any leaks a result of failure of the pipeline footings
Rehabilitation	Vegetation rehabilitation of Barney Creek & McArthur River diversions	Channel erosion, poor water quality and changes to the riparian community species	L	WM	Inadequate rehabilitation of the river diversions	River diversion rehabilitation program and monitoring.	3	3	**6**	M	Monitoring results not available in this reporting year therefore complete assessment not undertaken. Increased habitat enhancement e.g. snags of wood debris should be installed in diversions to increase fish habitat and

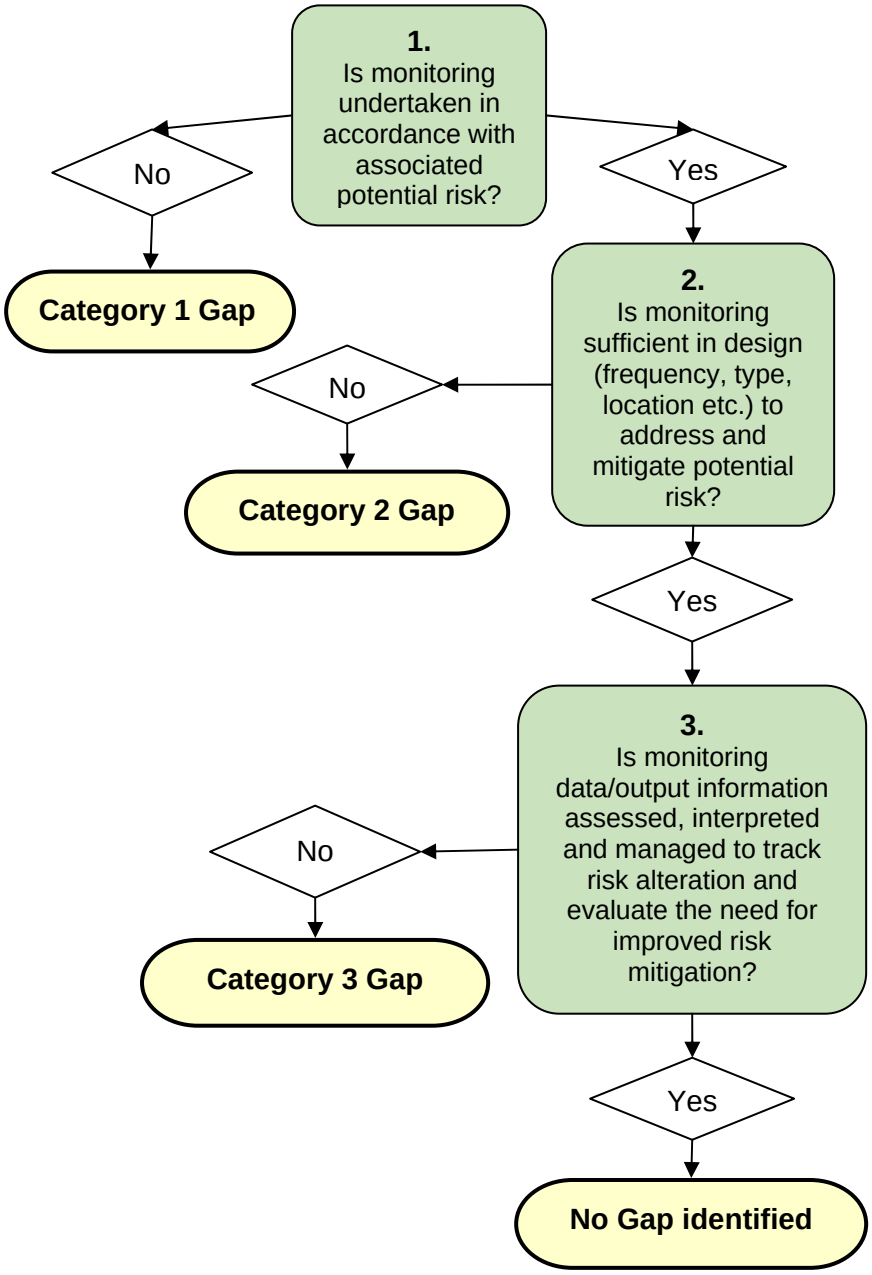
Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
											reduce erosion.
River diversions	McArthur River diversion	Potential impact on aquatic flora & fauna environment	S	P	ford construction for river crossing	Unknown	4	2	**6**	M	Assessment to be undertaken
River diversions	Barney Creek & McArthur River diversions	Flooding within mine pit	S	L	Very rare flood event (>500 years ARI)	Monitoring of flood warning station telemetered information	1	5	**6**	M	It is unclear whether current flood warning scheme addresses such an abnormal event. If not, scheme should be re-assessed.
Soil /sediments	TSF, OEF, Bing Bong dredge spoil	Development of salt and/or heavy metal loads in vegetation, soils and sediments	M	OM	Poor dust management and control	Dust monitoring programme and dust mitigation measures, proposed and actual rehabilitation trials (BB, TSF Cell 1)	3	3	**6**	M	Rehabilitation efforts of dredge spoil area need to be increased. Area showing little revegetation cover and evidence of cattle accessing rehabilitation. Additional dust monitoring sites should be installed around dredge spoil area adjacent to remnant vegetation to assess of-site impacts.

Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
Surface Water	Mine water extractions	Water extraction impacts aquatic flora and fauna	E	OM	Over-extraction reduces dry season flows in river	'Gauge board' system in place, and extraction limits imposed by DRDPIFR.	3	3	**6**	M	Additional information regarding method of measuring river flows should be provided.
River diversions	McArthur River diversion	Loss of diversion wall due to flooding and unplanned overland flow from the old McArthur River Channel into diversion channel.	E	L	Flood flows returning to river from the direction of the remnant river channel. Eroding toe of diversion channel.	None	2	5	**7**	M	Hydraulic flood modelling to be undertaken to determine extent of potential scour and subsequent reporting of as-necessary remedial works to provide long term scour protection solution
Dredge Management	Bing Bong Port	Loss of seagrass	M	WM	Impacts to seagrass from turbidity during dredging operations	Annual seagrass monitoring program.	4	3	**7**	M	Results indicate that seagrass in vicinity of port are being periodically exposed to concentrate derived lead, although seagrass appears to be increasing.
Fauna	Mollusc monitoring at Bing Bong Port	Bioaccumulation metals within molluscs in Bing Bong Port harbour.	M	L	Contamination of metals from port operations	Mollusc monitoring programme	3	4	**7**	M	Concentrations of elevated metals higher in specimens sampled in the Western beach than Eastern beach. Future sampling to include monitoring for inorganic arsenic. Water quality monitoring appears sufficient.

Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
Flora	Rehabilitation of Barney Creek & McArthur River diversions	Erosion and stock causes damage to rehabilitation.	M	WM	Poor or delayed rehabilitation of diversion channels, and broken fences let cattle and donkeys on site.	Re-channelling erosion assessment prepared in years 1,3,5 and 10 and as required until mine closure; fences in place to keep cattle and donkeys out (however these have been damaged).	4	3	**7**	M	Increase rehabilitation efforts increase planting of tube-stocks prior to wet season; and repair fences immediately after wet season to keep cattle out.
Groundwater	Regional groundwater and dependent ecosystems	Complete depressurisation of aquifers, reduction in yield and water quality.	M	OM	Excessive drawdown of aquifers due to dewatering for mine pit and water supply	Groundwater monitoring.	3	4	**7**	M	Calibration of the groundwater modelling undertaken in 2006 (EIS) should be undertaken annually and the model re-run every 5 years.
Seawater quality	Bing Bong Port	Contamination of seawater with heavy metals causes bioaccumulation in flora and fauna and contamination of sediments.	M	OM	Dust / spills from ship-loading operations	Dust management measures, stockpile control measures, and ship loading procedures.	3	4	**7**	M	Continued monitoring of ship-loading procedures and dust mitigation measures, and further investigation into fugitive dust emissions.
Soil/sediment	McArthur River and Barney Creek.	Bioaccumulation of metals in flora and fauna within or around river diversions.	M	WM	Dust from mining operations and changes to creek flows. Elevated metal concentrations at downstream monitoring sites at FS03 and FS05.	Sediment monitoring program	3	4	**7**	M	Dust mitigation measures should be reassessed to increase frequency of water spraying at Rom pad and Pacrim yard, for example. Sediment monitoring data and interpretation should be included in the AER to effect thorough assessment of sediment monitoring results.

Monitoring Area	Monitoring Sub-area	Potential Hazard/ loss scenario	Potential duration of impact	Location of impact	Causes	Existing Controls/ Monitoring and Assessment undertaken	Consequence	Likelihood	Matrix Result	Risk Rating	Additional Controls, monitoring , assessment or actions required
Flora	Vegetation clearing - Barney Creek & McArthur River diversions	Vegetation cleared in a manner that does not allow fauna to move away from disturbance.	M	WM	Broad-scale clearing undertaken rather than progressive clearing	Clearing permit	3	4	**7**	M	Continued use of Clearing Permit process.
Groundwater	Mine site and Bing Bong	Impact on groundwater quality and beneficial uses from hydrocarbons, reagents and other liquid products used at mine and Bing Bong	M	P	Vehicle movement over sub-surface fuel and liquid pipelines, corrosion of infrastructure, accidents and spills.	Groundwater and surface water monitoring; various inspection procedures of pipelines and infrastructure; incident report forms.	4	3	**7**	M	Integrity testing of fuel tanks and pipelines should be undertaken in conjunction with a hydrocarbon audit of the facilities.
River diversions	Barney Creek & McArthur River diversions	Sudden and significant flood-induced channel bank erosion/collapse leads to unexpected increase in flood level	S	L	Flood event	OPSIM Modelling	4	4	**8**	L	Ensure OPSIM modelling accounts for extreme and severe rainfall events and significant channel bank erosion.

APPENDIX C GAP ANALYSIS PROCESS FLOW CHART



Independent Monitor gap analysis process.

APPENDIX D MONITORING GAP REGISTER

GAP REGISTER – GROUPED BY MONITORING AREA

Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
		1	2	3	
Mine Site					
Waste rock	Inadequate geochemical analysis and confirmation testing of waste rock and tailings.		x		IM advises that procedures should be updated to match practice and undertake accelerated trials of actual size.
Tailings geochemistry	Acid/base accounting			x	The IM advises that results be reviewed in terms of initial projections of tailings geochemistry, acid production and long term weathering effects.
Tailings geochemistry	Monitoring of water at the surface and within Tailings Cells 1 and 2	x			Monitor pH of ponded water at the surface of the cells and from within piezometers within TSF.
Civil works	Inadequate monitoring for loss of soil in diversion channel works (with related impacts on vegetation establishment).		x		The IM is unclear whether the monitoring is adequate/appropriate to address loss of soil. MRM are advised to produce ongoing series of channel photographs from opposite banks to 'mirror' current photo portfolios of both diversions and provide associated commentary in each reporting period, regarding changes which have taken place since previous photos were taken.
Civil works	Inadequate monitoring of diversion channel bank erosion/slumping		x		The IM cannot confirmation that spacing of photograph locations is adequate to identify all erosion /slumping. MRM are advised to produce ongoing series' of diversion channel photographs from opposite banks (to provide 'complete' picture). Reporting should include documentation of instances of erosion & associated repair works (with photographs of damaged condition and post-rectification works condition). Reporting should also provide commentary on size of flood/s which caused erosion.
Civil works	Lack of hydraulic engineering assessment of as-built diversion channels.	x			As-built details of channel cross sections should be inserted into design hydraulic model and results compared with design basis. Report should include a detailed comparison of any differences reported by the two models and the associated implications of those differences.
Civil works	Lack of assessment of erosion regime associated with flood-time overland flows passing from remnant McArthur River channel to diversion channel.	x			Hydraulic modelling be undertaken to formally assess the potential erosion issues, and associated preparation of a report which reports on potential need for associated works, along this flow path

Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
		1	2	3	
Civil works	Inadequate clay lining materials testing / compaction test results for OEF.	x			The URS Design Report specifies clay placement requirements and how it is to be measured. Without this information it is not possible to verify that the PAF cell linings have been correctly constructed.
Civil works	Absence of as-Built Drawings for OEF foundation, and geotechnical verification of foundation grades, topsoil, and any foundation soft spots to be removed.	x			Without this information it is not possible to verify that the OEF foundation has been correctly constructed
Civil works	There appears to be a lack of monitoring regarding TSF Cell 1 embankment. The current monitoring consists of visual inspections and water level monitoring (downstream of the toe), however, little is known about the geotechnical integrity of this asset.		x		MRM are advised to complete a 'Comprehensive Dam Inspection' and 'Dam Safety Review' for the TSF (including WMD) in accordance with the definitions described by ANCOLD 1999 and 2003. It is noted that the current condition downstream of Cell 1 embankment does not meet MRM's performance criteria in the 2007-2008 MMP Section 5.2.1
Civil works	Incomplete/not provided information on the design and construction of the water management dam (WMD) at the TSF.	x			Technical drawings, specifications and as-built reports for the WMD should be provided as part of the next Audit, and monitoring for geotechnical stability should be incorporated into mine management practices.
Civil works	Inadequacy of MRM Monthly inspections and reports regarding the TSF.		x		Periodic MRM visual monitoring appears to be completed by different personnel, which based on the information provided to the IM, may be leading to a lack of continuity in how the inspections are being completed and how issued are being followed through. Furthermore, the 'tick the box' approach to the regular inspections does not include monitoring groundwater levels (in Cell 2 embankment), nor is it clear as to exactly what areas were visited and what has changed since the last inspection. The IM recommends that the annual AWA (e.g. AWA, 2007) recommendations for TSF geotechnical monitoring are incorporated into the monthly geotechnical inspections of the TSF. The IM also recommends a review of the MRM TSF Operating Guidelines (Feb 2007) so that they comply with ANCOLD 1999 and 2003.
Civil works	Inadequate geotechnical monitoring/ reporting of TSF and WMD monitoring bore results.		x		2007-2008 MMP indicates that additional monitoring boreholes will be installed in the embankments of the TSF and WMD, and that piezometric levels will be monitored to determine any adverse impacts on stability. The IM has not viewed the results of such monitoring within the AWA annual inspection reports or any other MRM reports. A review of these piezometric levels should be included within the annual inspection scope of works, and documentation/interpretation of water levels is on a monthly basis is recommended.

Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
		1	2	3	
Civil works	Apparent lack of a Dam Emergency Response Plan for the TSF.	x			The 2007-2008 MMP (MRM, 2008a) indicates that an 'Emergency Tailings Dam Water Release Procedure ' has been developed; however, the IM has not sighted this procedure, which is a requirement of ANCOLD 1999. The 2007-2008 MMP refers to a site wide Emergency Response Plan, but it is unclear if all possible dam emergency scenarios are covered within this document. The IM would like to see evidence of a Dam Emergency Response Plan during the next Audit period.
Civil works	Lack of regular embankment quantified monitoring system for the TSF	x			As identified in the AWA 2008 annual inspection, survey pins should be installed to determine lateral displacement and settlement trends.
Civil works	Lack of as-built construction reports for McArthur River and Barney Creek River Diversions	x			It is understood that a construction report for these major works has not yet been completed.
Flora/fauna	Lack of mosquito breeding sites monitoring	x			Not being undertaken at present, however MRM have provided evidence of planning and stated commitment to do so.
Groundwater	Impacts of mine and TSF on local and regional groundwater.			x	Annual hydrogeological and hydrological "stand-alone" monitoring reports should be prepared by suitably qualified professionals to evaluate effects of seepage, and drawdown on aquifers, etc. Annual results should be compared against conceptual models.
Surface water	Fluvial sediment chemistry and physical particle size distribution has not been provided or interpreted within the AER (MRM, 2009a).			x	The IM recommends that chemical and physical monitoring and interpretation of fluvial sediment data be included in subsequent AERs.
Rehabilitation	Lack of fencing maintenance to keep cattle from destroying revegetation attempts along river diversions.		x		Fencing maintenance required to keep cattle out of rehabilitated areas, and reseeding should occur to improve revegetation cover. The IM has viewed evidence of MRM's planned re-fencing activities.
Surface water	Apparent discrepancies in water levels/flow levels recorded at upstream and downstream McArthur River gauges.			x	Assessment of apparent discrepancies should be undertaken, and associated report be produced on whether the data as recorded/reported is adequate for intended purposes.

Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
		1	2	3	
Surface water	IM is unclear of the methods employed for measurement of surface water flows for the purposes of complying with Government approval for water extraction for mine process needs.		x		Details of method used to explicitly measure surface water flows to be provided/reported.
Surface water	Inadequate reviews of condition of/performance of sediment control structures.		x		Current lack of formal reports of inspections, and results of quantitative measurements should be reviewed.
Surface water	Lack of warning system for an extreme flood event	x			The consequences of a flood which is similar in size or larger than that which would overtop the levee wall are very serious. The current flood warning water level data reporting system is advised to be upgraded such that the relative size of a flood coming down the McArthur River can be measured and urgently reported.
Bing Bong Port and McArthur River Delta					
Surface water	Lack of monitoring of seepage water through Bing Bong dredge spoil walls.	x			Monitor water quality and vegetation outside dredge spoil dam walls to ensure seepage is not causing impact to flora.
Surface water	Lack of monitoring to assess whether Dredge soil drain is effective in draining saline water from dredge ponds to sea as designed.	x			Confirm through surveys regular monitoring that dredge water and seepage drains flow to the sea.
Surface water/ artificial water	Lack of records indicating monitoring of Bing Bong Surface Runoff Pond (BBSRP) to prevent potential overflow.	x			Monitoring should be undertaken to ensure that sufficient freeboard is maintained and sediment regularly removed to minimise potential impacts from overflow. The IM, however, recognises that OPSIM modelling now includes the Bing Bong facility.
Civil works	There is no documentation regarding design/construction or subsequent geotechnical monitoring of the Bing Bong Spoil Facility.	x			MRM are advised to reassess the strategy for the use of this facility, then develop an engineered solution in the context of the proposed future usage.

APPENDIX E PHOTOGRAPH PLATES

Plate 1 - Iron sulfates along beached areas of ponded water at the surface of TSF Cell 1, indicating acidic conditions (June 2009).

Plate 2 - Salt crystalisation along Surprise Creek. Photograph taken facing up stream (June 2009).

Plate 3 - Layer of dark fugitive dust from ROM pad area, on the access road at the foot of the ROM Pad (June 2009)

Plate 4 - Area of soil contamination beneath the Bing Bong Port load out conveyor sump/ drain where bitumen had eroded expose the soil beneath (June 2009).

Plate 5 - McArthur River ford crossing. (Note log on bank deposited during wet season flood). (June 2009).

Plate 6 - McArthur River bank erosion/slumping (June 2009).

Plate 7 - McArthur River bank erosion/slumping (June 2009).

Plate 8 - Barney Creek Ch 500m (July 2008)

Plate 9 - Barney Creek Ch 500m (March 2009).

Plate 10 - McArthur River overland flow-path from remnant channel (in right foreground) to diversion channel (in background) (June 2009).

Plate 11 - TSF abutment of TSF Pipeline Bridge over Barney Creek (June 2009).

Plate 12 - Cell 1 downstream northern embankment, approximately midway along, adjacent to Surprise Creek (June 2009).

Plate 13 - TSF Cell 1 upstream northern embankment, approximately midway along. Ponded water on top of TSF (June 2009)

Plate 14 - Surprise Creek channel bank exhibits evidence of continued steady seepage through the presence of salt and iron below northern embankment of Cell1. Closer inspection shows that the rocks have been eroded. (June 2009).

Plate 15 - Washout below TSF Cell 1 northern embankment, approximately midway along. Considerable surface expression of salt (June 2009)

Plate 16 - Extensive surface salt downstream of second erosion gully approximately midway along northern embankment of TSF Cell 1. Seepage possibly along soil/rock interface (June 2009).

Plate 17 - MRM remediated ROM sump following overtopping during 08/09 wet season (June 2009).

Plate 18 - Reconstructed road after washout that resulted from sump overflow (June 2009).

Plate 19 - Barney Creek river diversion works with rock armouring (June 2009).

Plate 20 - Minor scour of rock armour can be seen within Barney Creek river diversion channel protection works (June 2009).

Plate 21 - Minor scour of rock armour can be seen within Barney Creek (foreground) and more advanced bank scour in Surprise Creek (top right corner) (June 2009).

Plate 22 - More advanced scour of Surprise Creek channel bank and resultant bank instability (June 2009).

Plate 23 - McArthur River diversion at upstream end (June 2009).

Plate 24 - McArthur River diversion, rockier section, towards upstream end (minor slumping resulting in screen pile in channel) (June 2009).

Plate 25 - McArthur River diversion, rockier section, towards upstream end (some minor wedge failures as weaker material has been washed out leaving unstable harder blocks) (June 2009).

Plate 26 - McArthur River diversion, rock armour where the channel banks have a more soil profile (June 2009).

Plate 27 - Overburden Emplacement Facility cell currently under construction. Clay paddock dumped in front of current dump lift (June 2009).

Plate 28 - Bing Bong spoil dump embankment with downstream spoon drain. Embankment deeply eroded and in disrepair (June 2009).

Plate 29 - Bing Bong spoil dump embankment with downstream spoon drain. Embankment deeply eroded and in disrepair. Salt crystalisation deposited from seepage can be seen on the outside of spoil wall (June 2009).

APPENDIX F LIST OF DOCUMENTS PROVIDED BY MRM TO THE INDEPENDENT MONITOR FOR REVIEW

LIST OF DOUCMENTS SUPPLIED TO THE INDEPENDENT MONITOR BY MRM FOR THE 2008 OPERATIONAL PERIOD

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
General Reports	**Environmental Incidents**	Incident 1	Incident #26750	20/02/2008	Minor oil spill from truck incident form
		Incident 2	Incident#26688	18/01/2008	Oil spill from truck incident form
		Incident 3	Incident#26698	18/01/2008	Minor Herbicide spill incident form
	Mining Management Plan	GEN-HSE-PLN-6040-0003 Mining Management Plan v1final 120208	Mining Management Plan 2007-2008	12/02/2008	Mining Management Plan 2007-2008
		Appendix A-R	Appendices A-R of Mining Management Plan 2007-2008	12/02/2008	Mining Management Plan 2007-2008 Appendices A-R
		LETT 071011 MMP Submission letter signed.gt	Submission of McArthur River Mine 2007-2008 Mining Management Plan - Letter to DPIFM	11/10/2007	Letter to DPIFM accompanying the MMP 2007-2008
	Request for changes	Changes on concentrate storage and approval 0811	The storage of concentrate at McArthur River Mine (letter to DPIFM), and Re: McArthur River Mine Project - Sampling schedule/analysis temporary storage of concentrate (response letter from DPIFM to MRM).	25/11/2008 02/04/2009	Proposed changes to concentration storage of MRM and DRDPIFR approval letter including analytical requirements.
		Changes on water abstraction 0807	Water abstraction for McArthur River Mine (Letter to DPIFM from MRM) and McArthur River Project - Water abstraction amendment to the McArthur Mine River Mining Management Plan (Response letter from DPIRM to MRM)	17/07/2008 11/08/2008	Proposed changes to water abstraction plans and DPIFM acceptance.

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
		Changes on TSF, Dump and Skeet complex with approval 0806	Amendments to the McArthur River Mine Mining Management Plan (Letter to DPIFM) and Re: McArthur River Project- Amendments to the McArthur Mine River Mining Management Plan (response letter from DPIFM to MRM).	25/06/2008 30/07/2008	Proposed changes to TSF, Dump and skeet complex and DPIFM approval letter.
		LETT 080611 EPBC Submission for MRM EPBC committments.GT	Submission as per Commonwealth Approvals for McArthur River Open Cut Project (Letter to Hon Peter Garrett from MRM).	10/06/2008	Letter from MRM to Hon Peter Garrett stating compliance with EPBC 2003/954 monitoring conditions.
		Letter from commonwealth on acceptance of EPBC commitment s	(No title) Response letter from the Australian Government Department of the Environment, Water, Heritage and the Arts to MRM.	15/08/2008	Letter response from the commonwealth government regarding MRM's compliance letter of 10/06/2008.
	Annual Environmental Report	2008 MRM AER Final Version_DRDPIFR update_Jan09	McArthur River Mining Pty Ltd Annual Environmental Report 2005-2008	Jan-09	Annual environmental report for the period 2005-2008.
	Environmental Monitoring Manual	GEN-ENV-MAN-6040-0001 Environmental Monitoring Manual 2007	McArthur River Mining Pty Ltd technical manual for environmental monitoring	unknown	
		GEN-ENV-MAN-6040-0001 Environmental Monitoring Manual 2009	McArthur River Mining Pty Ltd Environmental Monitoring Manual 2009	5/06/2009	
	Waste Management Plan	PLN 090427 Waste Management Plan-JSB	McArthur River Mining Pty Ltd Waste Management Plan May 2009	May-09	

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
Water	**Changes and details of monitoring regime**	Sampling and schedule changes request and approval 0812	Mining Management Plan amendment - Sampling Schedule/Analysis (Letter from MRM to DRDPIFR) and Re: Mining Management Plan Amendment - Sampling Schedule/Analysis(response letter from DRDPIFR to MRM).	11/12/2008 24/12/2008	Proposed changes to analytical schedule for water analysis and approval letter from DRDPIFR.
		Sampling and schedule changes request and approval 0903	Mining Management Plan Amendment - Sampling Schedule/Analysis (Letter from MRM to DRDPIFR) and Re: McArthur River Mine Project - Sampling schedule/analysis and temporary storage of concentrate (response letter from DRDPIFR to MRM).	11/03/2009 02/04/2009	Proposed changes to analytical schedule for water analysis and approval letter from DRDPIFR.
	Field Sheets	ASW 0807	Artificial surface water quality monitoring - Sample data form	7/07/2008	unclear what area is being sampled here.
		GW 080818	Groundwater monitoring - Field data sheets	18/08/2008	
		GW 080821	Groundwater monitoring - Field data sheets	21/08/2008	
		GW 080825	Groundwater monitoring - Field data sheets	25/08/2008	
		GW 080828	Groundwater monitoring - Field data sheets	28/08/2008	
		SW 080804	Natural Surface Water Sample Data Form	4/08/2008	
		SW 080807A	Natural Surface Water Sample Data Form	7/08/2008	
		SW 080807B	Natural Surface Water Sample Data Form	7/08/2008	
		SW 080814	Natural Surface Water Sample Data Form	14/08/2008	
		SW 080821A	Natural Surface Water Sample Data Form	21/08/2008	
		SW 080821B	Natural Surface Water Sample Data Form	21/08/2008	
		SW 080828	Natural Surface Water Sample Data Form	28/08/2008	

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
	Groundwater reports	090226 URS Scoping document	Memorandum - Objectives of Groundwater Modeling	26/02/2009	
		CMcHunter confirm	SAM Mc Arthur River travel Itinerary	5/03/2009	
		Commitment by MRM to DRDPIFR on groundwater and OPSIM studies	Annual Environmental Monitoring Report 2005-2008	11/03/2009	
		MRM Hydrological Study Mar 09	Hydrological Study	Mar-09	
		Progressive invoice for Groundwater model through URS	URS-Tax invoice	30/04/2009	
		URS Proposal - Site Water Management Plan	Proposal-Mc Arthur River Mine-Development of a Site Water Management Plan	9/03/2009	
	Lab Results	ASW 080707 EL11184 MRM		7/07/2008	
		GW 080818 EL11650 MRM		18/08/2008	
		GW 080821 EL11675 MRM		21/08/2008	
		GW 080825 EL11689 MRM		25/08/2008	
		GW 080828 EL11731 MRM		27/08/2008	
		SW 080804 EL11466 MRM		4/08/2008	
		SW 080807 EL11524 MRM		7/08/2008	
		SW 080814 EL11605 MRM		14/08/2008	
		SW 080821 EL11674 MRM		21/08/2008	
		SW 080828 EL11729 MRM		28/08/2008	
	OPSIM	2007_08_23 Water System schematic August 2007	MRM Site and Concentrator Water System Overview Schematic August 2007	Aug-07	

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
		OPSIM _draft	OPSIM Water Management _ Update & Review - September 2007	Sep-07	
		progressive invoice for 2009 OPSIM model	Progress Invoice NO3_Site Water Management-OPSIM Update 2009	27/05/2009	
	TSF Recovery Bores	ADM-ENV-FRM-6040-0013 Recovery Bore Monitoring Data Sheet I	Recovery Bore Monitoring Data Sheet		
		Recovery Bore Bata Exported 090604		13/05/2009	
	Discharge licenses	**RPT 090303 DL169 Feb Report**	Discharge License 169 Monthly Report 1	February/march 2009	
		RPT 090410 DL169 March Report	Discharge License 169 Monthly Report 2	March/April 2009	
Dust and Soil	**DUST OCT07**	DUST DATA SHEET	Dust Monitoring-Sample Data Form	31/10/2007	
		EB0713041_0_ENMRG		31/10/2007	
		EB0713041_0_XTAB		31/10/2007	
		EB0713041_COA	Certificate of analysis	19/11/2007	
		EB0713041_COC	Dust Sample Submission Form	8/11/2007	
		EB0713041_QCI	Interpretive quality control report	19/11/2007	
	FLUVIAL SEDIMENT JUNE08	EB0807775_0_ENMRG		26/05/2008	
		EB0807775_0_XTAB		26/05/2008	
		EB0807775_COA	Certificate of analysis	20/06/2008	
		EB0807775_COC	Fluvial Soil Sample Submission Form	9/06/2008	
		EB0807775_QC	Quality control report	20/06/2008	

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
		EB0807775_QCI	Interpretive quality control report	20/06/2008	
		EB0807775_SRN	Sample receipt notification (SRN)	20/06/2008	
		FLUVIAL SEDIMENT DATA SHEET	Fluvial Sediment Collection-Sample Data Sheet	6/06/2008	
	SOIL JUNE08	EB0807778_0_ENMRG		30/04/2008	
		EB0807778_0_XTAB		30/04/2008	
		EB0807778_COA	Certificate of analysis	2/07/2008	
		EB0807778_COC	Soil Sample Submission Form	10/06/2008	
		EB0807778_QC	Quality control report	2/07/2008	
		EB0807778_QCI	Interpretive quality control report	2/07/2008	
		EB0807778_SRN	Sample receipt notification (SRN)	20/06/2008	
		SOIL DATA SHEET	Soil Sediment Collection-Monitoring Sample Data Sheet	6/05/2008	
Marine Monitoring	**Changes to Infrastructure**	Investment proposal for work conducted on the Bing Bong Con	Project; Replacement Roofing Bing Bong Concentrate Shed Investment Proposal	10/10/2008	
		Bing Bong Sprinklers 001	(photo)	5/03/2009	
		Bing Bong Sprinklers 003	(photo)	5/03/2009	
		Bing Bong Sprinklers 008	(photo)	5/03/2009	
		Bing Bong Sprinklers 009	(photo)	5/03/2009	
		Bing Bong Sprinklers 012	(photo)	5/03/2009	
	AMD monitoring using microbial mats CDU research		Project description		
	ARD microbial mats project		managing acid mind drainage in northern Australia using microbial mats		

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
	Assessment of metal pollution at Bing Bong Loading Facility		Monitoring program to assess the impact of metal pollution at bing bong loading facility on listed migratory birds - report on survey 22-24 January 2008	27/03/2008	
	Bing Bong Dec2008 final NCM 110509		Bing Bong Annual Monitoring Report, December 2008: Elemental concentrations in seawater, sediment and biota	Apr-09	
	Coastal Monitoring using metal resistant microbes CDU Research		Project description		
	Managing acid mine drainage contribution		Confirmation of partner organisation contributions for 2008	7/04/2009	
	MRM BB DGT final		Report on trial of Diffusion Gradients in Thin-film (DGT) devices to monitor bio-availability of metals in seawater at the Bing Bong Load-out Facility	Jul-07	
	RPT 080315 Final Migratory Birds		Monitoring program to assess the impact of metal pollution at bing bong loading facility on listed migratory birds - final report	15/04/2008	
	Seagrass annual report final 2007		Annual Seagrass Survey of Port Bing Bong - December 2007 - Final Report	Mar-08	
	SEPI Dec2008 final NCM 150409		Sir Edward Pellew Islands study December 2008: Elemental concentrations in seawater, sediment and oysters	Apr-09	
Flora and Fauna	**Bird Studies**	MRM RB Colour Banding 2007 FINAL 11 June 2008	McArthur River Riparian Bird Colour Banding project	Jun-08	
		MRM Riparian Bird Monitoring April 2008 - Final 20 May 2009	McArthur River Riparian Bird Monitoring	April-May 2008	

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
		MRM Riparian Bird Monitoring Nov 2007 Final 20 March 2008	McArthur River Riparian Bird Monitoring - Late Dry Season - Final Report	Oct/Nov 2007	
		MRM Riparian Bird Monitoring October 2008 Final 20 May 2009	McArthur River Riparian Bird Monitoring - Final Report	Oct-08	
		RPT 070415 Riparian Bird Monitoring April 2007 - Final	McArthur River Riparian Bird Monitoring - Late Wet Season - Final Report	Apr-07	
	Riparian Vegetation	MRM Vegetation Rehab report April 08	Assessment of the riparian vegetation established on river channels near the McArthur River Mine	Apr-08	
	Sawfish Monitoring	2007 / Oct 07 Survey / RPT 071020 late dry season 07 Report FINAL	Interim report on the fish and aquatic invertebrate fauna of the McArthur River, Northern Territory, and investigation of seasonal distribution data	Apr-08	
		2008 / April 08 Survey / 08003 May Report V2 To client Lock	Interim report on the fish fauna of the McArthur River, Northern Territory	May-08	
		2008 / November 08 Survey / 08003 November 08 Report FINAL TO CLIENT lock	Report on the fish fauna of the McArthur River, Northern territory, 2006-2008	Feb-09	
	Weed Management	Weed Management Plan 2009	Weed Management Plan 2009	Apr-09	
Dredge Spoil	**Proposed studies**	Bing bong Plan1	Experiment 1: Effect of two treatments (control & all) and three topographical positions (Upper flat, slope & lower flat) on germination of five plant species. Experiment 2: Effect of different levels of amendments (control, gypsum, chemical fertilizers, mulch & combination) on germination of two plant species (one grass and another tree).		

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
		Bing Bong proposal 2007l	Enhanced native vegetation community development on the Bing Bong Dredge Spoil	Jan-07	
		Earthwork details	Details of the proposed earthworks on the Bing Bong dredge spoil site		
		Proposed schedule June 08 field trip			
	DRDPIFR letter for acceptance and acknowledgment		McArthur River Project-Bing Bong swing basin 2008 dredge program environmental management plan	9/09/2008	
	PLAN 080815 Dredge Management Plan Final - CLJ		Environmental Management Plan - Bing Bong Swing Basin 2008 Dredge Program	2008	
Civil Works	**Civil works rock sampling procedure**	PRO 071030 Rock Sampling - JSB	Barney Creek/McArthur River Rechanneling Rock Sampling Procedure		
	Ore Grade Control Procedure	EDIT_MIN_TEC_SOP_1000_0007_Ore Spotting and Grade Control	Ore Spotting and grade Control		
	Results of NAFPAF Testing	BR07140275		4/02/2008	
		EB0800012_0_ENMRG		22/12/2007	
	Rock sampling data sheets	REG 071121 Barney Rock Sampling Data - JSB	Rock Sampling Data Sheet	21/11/2007	
		REG 071223 McArthur Rock Sampling Data - JSB	Rock Sampling Data Sheet	22/12/2007	
	Rock sampling JSA	JSA 071030 Rock Sampling - JSB	Job Safety Analysis Worksheet		
	Final Report OEF Design		McArthur River Mine-Overburden Emplacement Facility (OEF) Design-Open Cut Project	30/07/2008	
Rehabilitation		GEN-ENV-PLN-6040-0005 Rechannel Rehabilitation Plan I001 Re	Rechannel Rehabilitation Plan	Jun-09	

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
		Rehabilitation of the Tailings Dam contract	Xstrata Zinc Lead Contract Approval Request Executive Summary	Jan-09	
		TSF Cell 1 Rehabilitation Stage 1 proposal form	Investment proposal form	8/05/2008	
		Xstrata - McArthur River Mining Phase 1 & 2 Report - Draft	Development of a Conceptual Cover System Design for Closure of the Tailings Storage Facility Cell #1	Jun-07	
		Xstrata_Zinc_MRM_Closure_Plan_20080325 final	Preliminary Mine Closure Plan	Mar-08	
Mosquito breeding monitoring		2009 May 12 Quote McArthur River mine routine mosquito monitoring	Mosquito monitoring program at McArthur River Mine	12/05/2009	
		090226 Admin Safety Meeting.gt	Safety minutes	26/02/2009	
		Guidelines for preventing mosquito breeding sites association	Guidelines for preventing Mosquito Breeding Sites Associated with Mining Sites	Nov-05	
		Mosquitoes factsheet[1]	Mosquitoes - Centre for Disease Control fact sheet	May-2006	
		procedures for setting traps	Procedure for setting out carbon dioxide baited mosquito light traps for surveillance	May-94	
		RE McArthur River mine routine mosquito monitoring program	RE: McArthur River mine routine mosquito monitoring program	12/05/2009	
		Signed letter for mosquito program implementation	Mosquito monitoring program at McArthur River Mine	2/06/2009	
MRM and Barney Diversions	**As built Report**	Proposal on Construction Report	Proposal for Preparation of Construction Report McArthur River Mine - Civil Expansion - Levee and Diversions	5/05/2008	
	Barney Creek Sediment Survey Photographs	BCS 080620 AJD	(photo)	20/06/2008	

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
	McArthur River LogPlacement photographs	McRLOGPLACEMENT 081021 AJD	(photo)	21/10/2008	
	McArthur River Sediment Survey 09/0 m 0616215 8181126/MARCH 09	McRSS090311AJD	(photo)	11/03/2009	
		McArthur River Civil Works Area Inspection 1	McArthur River Mining planned area inspection checklist-civil work area		
		McArthur River Civil Works Area Inspection 2	McArthur River Mining planned area inspection checklist-civil work area		
		sediment report 3	Sediment and Erosion Control-Inspection Report-Feb07	Feb-07	
Weed Management	**Weed Management Plan 2006**	Weed Management Plan 2006 V2 JNC	Weed Management	Apr-06	
		Weed Management Plan 2008 vers 2 FINAL feb	Weed Management Plan	Jan-08	
		Weed Management Plan 2009	Weed management Plan 2009	Apr-09	
Revegetation	**2) Feedback to Stakeholders regarding revgetation**	090415_MRM_Memorandum edition 10_final	Memorandum	Apr-09	
		ADM-CRE-PRO-6020-0015 External Communication procedure I001	External Communication Procedure	Nov-07	
		MCARI6257_Newsletter_Jan08	Memorandum	Jan-08	
		MCARI6409_Newsletter_final			
		MCARI6564_AugustNewsletter_FINAL			
		Memorandum - edition 6			
	Native Seed Invoices	Native Seed Invoices	Top End Seeds Invoice	1/10/2007	
	Revegetation monitoring	MRM Vegetation Rehab report april 08	Assessment of the riparian vegetation established on river channels near the McArthur River Mine	Apr-08	Report by Sean Bellairs - Charles Darwin University

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
Water Abstraction	**Abstraction of water from McArthur River**	Southern Cross Extraction Totals		11/08/2008	
NAF Materials in Civil works	**Civil works - material used were mapped and NAF**	PRO 071030 Rock Sampling - JSB	Barney Creek/McArthur River Rechannelling Rock Sampling Procedure		Duplicate- already provided on Disc One.
	Ore Grade Control Procedure	EDIT_MIN_TEC_SOP_1000_0007_Ore Spotting and Grade Control	Mine technical services - Ore spotting and Grade Control	no date	Procedure for spotting ore for material control and classification in the open pit.
	Results of NAFPAF Testing	Results of NAFPAF Testing	BR07140275	4/02/2008	Laboratory testing of rock samples
			EB0800012_0_ENMRG	22/12/2007	Laboratory testing of rock samples
	Rock Sampling Data Sheets	REG 071121 Barney Rock Sampling Data - JSB	Rock Sampling Data Sheet	21/11/2007	
		REG 071223 McArthur Rock Sampling Data - JSB	Rock Sampling Data Sheet	22/12/2007	
	Rock sampling JSA	JSA 071030 Rock Sampling - JSB	JSA- Rock Sampling	na	example JSA template
Perimeter fencing	**17 km Perimeter Fencing to prevent stock movement**	Perimeter Fence Invoices	Remote mining and maintenance Pty Ltd invoice	7/11/2007	Order for 17 km of fencing.
	2009 Fence Maintenance Quote	833 - MRM	All fencing Services NT Quote	24/04/2009	Quote for fence repair and installation of additional fencing
	2008 October Meeting Minutes	MEET 081002 October Meeting Minutes	Minutes 2/10/2008	2/10/2008	Health Safety Environment & Community Committee Meeting minutes
	Quarantine Fence	Quarantine Fence	Photo	no date	Aerial photograph showing schematic location of perimeter fence.

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
Fish barrier rectification	**Photo of potential fish barriers**	P5150015	Photo P5150015	no date	Photo of creek with fallen woody debris
Tailings dam design	**Tailings design - Spill mitigation**	14103250 File Note 020108	File Note: Tails Line Leak detection and Wear Detection.	21/01/2008	MRM file note to define options available for leak detection and to decide on circuit to finalise P&ID for Thickener.
		File Note Tails Diameter and pump selection	File Note: Tails Line Size & Pumps	10/05/2007	Data for Expansion to 3.5 Mtpa – 2.5 Mtpa Expansion
		File Note Tails Line Design Parameters 090602	File Note: Tails Line Design Parameters	2/06/2009	As part of the 2.5 Mtpa expansion, it was identified that the existing 200 NB tailings pipeline required up-grading.
		File Note TAILS PUMPS 120707	File Note: Tailings Pumps Selection	12/07/2007	A new 36m diameter tailings thickener has been purchased. A new tailings 300 NB line will be run from the new tailings disposal pumps to the corner of the dam wall.
		MRM Tailings Line Design 071120	MRM Tailings Line: Discussion on Expansion Considerations for the New 300NB Tailings Line	7/11/2007	The existing 200NB Victaulic-coupled rubber-lined steel pipeline is being upgraded and replaced by a new 300NB flanged rubber-lined steel

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
					pipeline.
Tailings pipeline	**Tailings Pipeline**	Tailings Pipeline Thickness Test Result	Tailings Pipeline Thickness testing		Excel Sheet only
		Tailings pipeline thickness test work order and completion	CONMECH Work Order	10/03/2009	Pipeline trials.
TSF Structural monitoring undertaken	**Tailings Dam**	2008_04 April Monthly Report	Tailings Storage Facility Monthly Operating Report	May-08	
		DAM Safety Review Report Allan Watson and Associates 2008	McArthur River Mining Pty Ltd - McArthur River mine Tailings Storage Facility Dam Safety Review Report (2008)	Dec-08	Report by Allan Watson Associates
		Mcarthur River Tailings Dam and Surrounds 1 Jan 08	McArthur River Mining Corrective Action report Tailings Dam and Surrounds (Template)- and Inspection checklist sheet.	6/01/2008	
		Mcarthur River Tailings Dam and Surrounds 2 March 08	McArthur River Mining Planned area inspection checklist Tailings Dam and Surrounds	13/03/2008	
		Mcarthur River Tailings Dam and Surrounds 3 May 08	McArthur River Mining Planned area inspection checklist Tailings Dam and Surrounds	3/05/2008	
		Mcarthur River Tailings Dam and Surrounds Inspection April 09	McArthur River Mining Planned area inspection checklist Tailings Dam and Surrounds	16/04/2009	
Tailings Geochemistry	**Tailings geochemistry**	April 08-Aug 08	Geochemistry lab results	Apr-Aug 2008	Sample collection and processing forms and lab transcripts
		Jan 08-Mar 08	Geochemistry lab results	Jan-Mar 2008	Sample collection and processing forms and lab transcripts

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
		Sep-08	Geochemistry lab results	Sep-08	Sample collection and processing forms and lab transcripts
	Structural surveillance of TSF	2008_04 April Monthly Report	Tailings Storage Facility Monthly Operating Report	May-08	
		DAM Safety Review Report Allan Watson and Associates 2008	McArthur River Mining Pty Ltd - McArthur River mine Tailings Storage Facility Dam Safety Review Report (2008)	Dec-08	Report by Allan Watson Associates
		McArthur River Tailings Dam and Surrounds 1 Jan 08	McArthur River Mining Corrective Action report Tailings Dam and Surrounds (Template)- and Inspection checklist sheet.	6/01/2008	
		McArthur River Tailings Dam and Surrounds 2 March 08	McArthur River Mining Planned area inspection checklist Tailings Dam and Surrounds	13/03/2008	
		McArthur River Tailings Dam and Surrounds 3 May 08	McArthur River Mining Planned area inspection checklist Tailings Dam and Surrounds	3/05/2008	
		McArthur River Tailings Dam and Surrounds Inspection April 09	McArthur River Mining Planned area inspection checklist Tailings Dam and Surrounds	16/04/2009	
TSF water level monitoring	**Piezometric levels and water levels indicating pond monitoring - TSF**	Water management Dam and TSF spillway level readings	List of Inspection times for monitoring (?)	unclear	PDF of calendar dates (?)
	TSF Fenced and fencing inspected	Tails Dam Fence Repair Inv.	Remote mining and maintenance Pty Ltd invoice	14/08/2008	Invoice for repair…no evidence of regular inspection provided.
Rehabs	**Rehabilitation trials - TSF Cell 1**	area capped and reported in email form from site surveyor	email regarding vol. of clay for capping	15/05/2009	
		Daily update of water usage, clay placed and HSE info from CDE	Earth works summary - TSF	Dec-08	
		Rehabilitation of the Tailings Dam contract	Earth works contract for TSF Capping	8/09/2008	

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
		tax invoice progress claim from CDE to undergo rehab	CDE Capital Invoice	30/12/2008	
		TSF Cell 1 Rehabilitation Stage 1 proposal form	Investment proposal form - TSF Cell 1 Rehabilitation (Stage 1)	8/05/2008	
NAF Materials in Civil works	**NAF/PAF Overburden placed in clay cells**	MRM North OEF PAF cells May 2009_GT	PowerPoint presentation - PAF Cell Construction	unknown	
Waste Geochemistry	**Ongoing Geochemical testing of waste materials**	EDIT_MIN_TEC_SOP_1000_0007_Ore Spotting and Grade Control	Procedure: Ore Spotting and Grade Control	unknown	This procedure describes the necessary steps in ore spotting for material control and classification in the MRM open pit.
		NOEF	3D Computer-generated figure	unknown	
		NOEF Geology Samples (2)	Excel sheet- Sample collection log	Unknown	
		RE points of sampling etc	Email regarding NOEF Map	5/06/2009	
		Waste rock sampling quote from ALS	ALS Analysis quote	unknown	
		waste_class_memo	Memorandum: The background on waste classification at McArthur River Mine	5/06/2009	
Environmental Monitoring updates	**6-monthly updates on Environmental Monitoring**	Letter Request from DRDPIFR on monitoring results on a quart	RE: Quarterly submission of water quality data.	8/04/2009	
	Review of site-wide risk register	2009 MRM Risk Register	HSEC HAZARDS IDENTIFICATION AND RISK ASSESSMENT- Excel Spreadsheet.	Apr-09	
		GEN-HSE-PRO-6040-0004 Risk Management Procedure I001 Rev 0.doc	MRM Risk Management Procedure	unknown	This procedure describes the minimum

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
					requirement for hazard identification, risk assessment and control.
Environmental Incidents	**Reporting of environmental incidents**	GEN-HSE-PRO-6040-0002 INCIDENT REPORTING PROCEDURE I002 Rev	MRM Incident reporting procedure	Nov-07	This procedure provides the process for reporting of all HSEC incidents including near misses and community complaints at McArthur River Mining.
		Env. Incidents	3 examples of environmental incidents		
Bing Bong Port Operations	**Bing Bong port facility preventive maintenance program**	Action list for inspection of dust suppression system for Bi	Choose Improvement Actions-Microsoft Internet Explorer provided by Xstrata Queensland	unknown	
		McArthur River Bing Bong Port Operations	Bing Bong Port operations	23/12/2008	
		McArthur River Bing Bong Port Operations 3	Bing Bong Port operations	8/10/2008	
		McArthur River Bing Bong Port Operations 4	Bing Bong Port operations	13/05/2008	
		McArthur River Bing Bong Port Operations 5	Bing Bong Port operations	unknown	
		McArthur River MV Aburri	Corrective Action Report - MV Aburri	19/03/2008	
		McArthur River MV Aburri 2	Plan Area Inspection Checklist - MV Aburri	13/05/2008	
		McArthur River MV Aburri 3	Plan Area Inspection Checklist - MV Aburri	8/10/2008	
		Several Workplace safety observations completed at Bing Bon	Workplace Safety Observations	28/07/2008	
	Dredge spoil performance review at Bing Bong	Email from project engineer on site in regards to Dredge sp	Bing Bong dredge spoil	20/08/2008	

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
	Conveyor and vehicle declines		Conveyor Decline Portal 0905	26/05/2009	
			Main Decline Portal 0905	26/05/2009	
			MRM Conveyor Decline - Barricaded 20090604	4/06/2009	
			MRM Main Decline - Barricaded 20090604	4/06/2009	
	Barney Creek		9 photos	27/02/2007	
	Barney Creek		125 photos	7/03/2007	
	Barney Creek		29 photos	13/03/2007	
	McArthur River		30 photos	5/06/2008	
	Procedual Documents/6	GEN-ENV-PRO-6040-0017 Fauna Management Procedure I001 Rev 0.doc	Fauna Management Procedure	Nov-07	
	Procedual Documents/8/2007 Aerial Photograph Bitmap		2 photos	19/05/2009	
	Procedual Documents/8/2007 Aerial Photograph Mapinfo		3 photos	23/10/2007	cannot open
	Procedual Documents/8/2008 Aerial Photograph Bitmap		2 photos	19/05/2009	
	Procedual Documents/8/2008 Aerial Photograph Mapinfo		4 photos	31/10/08 & 3/11/08	cannot open

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
Additional information provided by MRM via mail and e-mail as per IM requests					
Tailings Storage Facility	**TSF life of mine plan**	r001-b (Total Report)	McArthur River Mining, McArthur River Mine Cell 2 (Stage 1) Tailings Dam Construction - Construction repot.	May-07	Report by Allan Watson Associates
	TSF Surface water	ASW TSF Oct07-Sept08	Surface water analytical results		
		SW Oct07-Sept08	Surface water analytical results - various locations	Oct07 to Sept 09	Excel spreadsheet
	TSF Groundwater	GW Data Oct07-Sept08	Groundwater data	Oct07 to Sept 08	
		Bores MW01-MW15 Oct07-Sept08	Groundwater data	Oct07 to Sept 09	
		Ind. Mon. - MPA, NAG, NAP & ANC	Tailings Monitoring for MPA, NAG, NAP & ANC	2007-2009	Excel spreadsheet
		SC Bores All Data	SC Bores All Data	Jun-09	
		URS bore details (rename)	URS Bore details and analysis	unknown	Excel spreadsheet
	Groundwater bores	URS-MRM Bore ID List	URS Bore details	Unknown	
		DrillLog_GW18			
		DrillLog_GW19			
		DrillLog_GW20			
		DrillLog_GW21			
		DrillLog_GW22			
		DrillLog_GW23			

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
		GW RL	Groundwater bore locations Aerial Photograph	unknown	Aerial photo
		LIST 070126 TSF Monitoring Well Details Jan 07 TS URS	Monitoring well details	Jan-07	Excel spreadsheet
		MRM Boreholes_TOTAL	Location and information regarding groundwater bores at MRM	Various	Excel spreadsheet
	Geochemistry	R001-B_Volume 1	URS report - Final Report - Geochemical Assessment of Overburden and Tailings Materials including Conceptual Designs of Overburden Emplacement Area Vol. 1 of 2	26/07/2005	
		R001-B_Volume 2	URS report - Final Report - Geochemical Assessment of Overburden and Tailings Materials including Conceptual Designs of Overburden Emplacement Area Vol. 2 of 2 Attachments D and E	27/07/2005	
	Inspections	2008_01_07 TSF Infrastructure Inspection	Tailings Storage Facility Infrastructure Inspection	7/01/2008	
		2008_01_26 TSF Infrastructure Inspection	Tailings Storage Facility Infrastructure Inspection	26/01/2008	
		2008_04_08 TSF Infrastructure Inspection	Tailings Storage Facility Infrastructure Inspection	8/04/2008	
		2008_05_03 TSF Infrastructure Inspection	Tailings Storage Facility Infrastructure Inspection	3/05/2008	
		2008_06_21 TSF Infrastructure Inspection	Tailings Storage Facility Infrastructure Inspection	21/06/2008	
		2008_07_31 TSF Infrastructure Inspection	Tailings Storage Facility Infrastructure Inspection	31/07/2008	
		09 04 16 McArthur River Tailings Dam and Surrounds Inspection	Planned area inspections checklist - tailings dam and surrounds	16/04/2009	
	TSF Annual report	2007 TSF Annual Report	2007 Tailings Storage Facility Annual Operating Report	28/01/2008	
	Monthly reports	2008_03 Jan- March Monthly Report	Tailings Storage Facility Monthly Operating Report March 2008	7/04/2008	

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
		2008_04 April Monthly Report	Tailings Storage Facility Monthly Operating Report April 2008	3/05/2008	
	TSF Dam Safety Review	AWA 2007 TSF Dam Inspection Report	MRM McArthur River Mine Tailings Storage Facility Dam Safety Review Report (2007)	1/09/2007	Alan Watson Associates
		AWA 2008 TSF Dam Inspection Report	MRM McArthur River Mine Tailings Storage Facility Dam Safety Review Report (2008)	December 2008	Alan Watson Associates
	Annual Life of Mine Plan	MET-GEN-PLN-2800-0001 TSF LOM Plan 2007	Tailings Storage Facility (TSF) Life of Mine (LOM) Plan 2007	1/12/2006	Date does not match up with date in document title!
		MET-GEN-PLN-2800-0001 TSF LOM Plan 2008	Tailings Storage Facility (TSF) Life of Mine (LOM) Plan 2008	2/12/2006	Date does not match up with date in document title!
		URS TSF Cell 1 Concept Design Rehab report	Tailings Storage Facility Rehabilitation - cell 1 concept design.	10/12/2004	
	TSF DESIGN/ Construction	MaunsellMcRept_Stg3_Cell1_Design	Cell 1 Tailings Dam Raising, Stage 3 Design Report	1/04/2001	Maunsell McIntyre report to McArthur River Mining
		STAGE 1 CONSTRUCTION SPEC	Stage 1 Raising of Cell 1 of the Tailings Dam - Construction Specification	1/08/2000	Maunsell McIntyre report to McArthur River Mining
		Stage 1 Construction Report-RevA	Cell 1 Tailings Dam Raising, Stage 1 Design Report	1/04/2001	Maunsell McIntyre report to McArthur River Mining
		STAGE 3 CONSTRUCTION SPECRevA	Stage 3 Raising of Cell 1 of the Tailings Dam, Job Specification MMPL Project 15000300, Revision A	4/04/2001	Maunsell McIntyre report to McArthur River Mining
		STAGE 3 CONSTRUCTION SPECRevC	Stage 3 Raising of Cell 1 of the Tailings Dam, Job Specification MMPL Project 15000300, Revision C	8/05/2001	Maunsell McIntyre report to McArthur River Mining

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
		STAGE 1 DESIGN REPORT	Stage 1 Design report for the proposed raising of cell 1 of the tailings dam	1/08/2000	Maunsell McIntyre report to McArthur River Mining
		Stage 3 Design Report RevA	Cell 1 tailings dam raising Stage 3 design report	1/04/2001	Maunsell McIntyre report to McArthur River Mining
		bowen-geotechreportamend	Memorandum - Tailings Dam Raises, McArthur River Mine	26/5/20060	Memorandum to P. Bowen (MRM) from Australian Mining Engineering Conusltants (AMEC)
		GeotechRept Tailings Dam Raises Using Tailings-Final	Geotechnical report on tailings dam raises using tailings, McArthur River Mine	May-04	Prepared by AMEC
		GeotechRept Tailings Dam Raises-MRM	Geotechnical report on tailings dam raises, McArthur River Mine	1/06/2003	Prepared by AMEC
		klibbereport-tailingsdamfailure_27Jan2003	McArthur River Mining Tailings Storage Embankment - Inspection report	27/01/2003	Prepared by AMEC
		MRM Water Mgmt Project Completion Report	Tailings and Water management project completion report, McArthur River mine	1/01/2002	Prepared by AMEC
		Report-Deterioration TailsDamEmbank-MRM_Jan2003	report on deterioration of tailings dam embankment, McArthur River Mine	1/01/2003	Prepared by AMEC
	Water management	Water Mgmnt Design- FINAL Report_FULL	McArthur River Mining Water Management Design Report	1/07/2001	Prepared by AMEC
		Geotech Report-Construct Dirty Water & Evap Dams	Geotechnical report for construction of dirty water and evaporations dams, McArthur River Mine.	1/08/2001	Prepared by AMEC

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
Environmental Incidents	**Concentrate spills**	Hamptons UTO's Incidents	5/09/2004		Photos
		Trailer Rollover 001116	Environmental Incident Reporting Form	16/11/2000	Incident form
		Con Spill Feb 2001	(Power point presentation)	no date	Power point presentation regarding Hamptons Truck Rollover
		Hamptons Spill Results	Hamptons Spill Results	21/1/2001 to 7/2/2001	Laboratory results of
		Trailer Rollover 010124	Environmental Incident Reporting Form	24.1.01	Incident form
		Locationmap	Location Map	26/01/2001	Map showing Concentrate spill location
		GEN-#1IY	MRM General Spill Response	Nov-07	Procedure
		GEN-#KX3	Major Concentrate Spill -Trucking incident	Nov-07	Emergency response procedure
	ROM Pad Incidents	090101 Rom Pad Sump Breach Images Incident #27291	Rom Pad Sump Bund Breach (Incident # 27291)		
		090203 ICAM ROM Pad Sump Breach.gt	Xstrata Zinc Commodity Business Unit incident investigation report - ROM Pad Bund Breach.	3/02/2009	
		090101 ROM Pad Sump Breach Incident #27291	Incident Notification Form	2/01/2009	
		090203 ROM Pad Sump Breach Images Incident #27	Rom Pad Sump Bund Breach (Incident # 27300)	3/02/2009	
Surface Water	**OPSIM Water Management**	2009 Draft OPSIM Report	OPSIM Water Management Update and review - March 2009	Mar-09	

Monitoring area	Sub-area	File name	Document name	Date	Comment/ Description
Surface Water	**Flood warning**	ADM-ENV-PRO-6040-0011 Early Flood Warning System I001 Rev 0	Early Flood Warning System Procedure	Mar-09	
	Adverse weather procedure	MIN-GEN-PRO-1000-0009 Adverse Weather Procedures I002 Rev 0.doc	Adverse Weather Procedure		
OEF	**Geotechnical**	OEF Survey Plans_DOC071609	OEF Survey Plans	20/06/2009	
Dredge spoil	**Soil sampling locations**	090618 Dredge Spoil Soil Sampling	090618 Dredge Spoil Soil Sampling - Aerial photograph	18/06/2009	Map showing sampling locations around Bing Bong Dredge Spoil since IM June 2009 Inspection.

APPENDIX G LIST OF DOCUMENTS PROVIDED BY DRDPIFR TO THE INDEPENDENT MONITOR FOR REVIEW

LIST OF DOUCMENTS SUPPLIED TO THE INDEPENDENT MONITOR BY DRDPIFR FOR THE 2008 OPERATIONAL PERIOD

Document	Type	*File name*	Document name	Date	Comment/ Description
Surface water and groundwater check-monitoring	**Excel spreadsheet**	*DRDPIFR Check Monitoring Data Oct 2007 - Dec 2008*	DRDPIFR Check Monitoring Data Oct 2007 - Dec 2008	Oct 2007-Dec 2008	Example of data.
Groundwater	**Document**	*McArthur River Mine GW monitoring program 09*	McArthur River Mine (MRM) Monitoring Program Groundwater	23/02/2009	
	Document	*McArthur River Mine SW Monitoring Program 09*	METHODOLOGY FOR THE SAMPLING OF SURFACE waters	Mar-08	
AER Report	**Report**	*MRM 200804 MR20080167 AER 2005-2007*	MRM Annual Environmental Report 2005-2007	Apr-08	
	Report	*MRM 200804 MR20080167 Appendix B (2)*	AER Appendix B: Dust monitoring - Various locations	Apr-08	URS monitoring reports
	Report	*MRM 200804 MR20080167 Appendix_A*	AER Appendix A:Water quality data for the McArthur River Monitoring Data	7/04/2008	URS monitoring reports
	Report	*MRM 200812 MR20081690 AER 2005-2008 Final Version*	MRM Annual Environmental Report 2005-2008	1/11/2008	Final Version of AER
	Report	*MRM 200901 MR20090005 AER 2005-2008 Final Approved Version*	MRM Annual Environmental Report 2005-2008	1/01/2009	Final Approved Version
AER Correspondence	**Letter**	*MRM 20070717 MDOC20071657 RequestForExtension_AnnualMonitoringReport*	Proposed changes to the monitoring plan (Letter)	17/07/2007	request from Gary Taylor to submit 2 monitoring plans at once

Document	Type	*File name*	Document name	Date	Comment/ Description
	Letter	*MRM 20070822 MDOC20071657 Response to Extension Request*	Response to Proposed changes to the monitoring plan (Letter)	22/08/2007	Response to the above
	Letter	*MRM 20071206 MDOC20072745 AER Submission Letter*	MRM Annual Monitoring report	6/12/2007	Letter to Peter Zeroni from Xstrata to address outstanding commitments from 2006-2007 MMP.
	Letter	*MRM 20071231 MDOC20072868 AER Submission Acknowledgement*	Re: report - annual monitoring report 2005-2007	11/12/07	Response to the above stating Annual Monitoring report 2005-2007 is undergoing review by DRDPIFR.
	Letter	*MRM 20080129 MDOC20080198 AER Rejection Letter*	Report - Annual monitoring report October 2005 to September 2007	29/01/08	Rejection of Annual Monitoring report submission 2005-2007.
	Letter	*MRM 20080408 MDOC20080915 AER Resubmission*	MRM Annual Monitoring report	4/04/08	MRM Letter accompanying re-submission of AMR
	Letter	*MRM 20080428 MDOC20081185 AER Resubmission Acknowledgement*	Annual monitoring report 2005-2007	28/04/08	DRDPIFR Letter of Acknowledgement of resubmission to MRM
	Letter	*MRM 20080529 MDOC20081603 AER Rejection Letter*	Report - Annual monitoring report October 2005 to September 2007	29/05/08	3rd Rejection letter to MRM
	Letter	*MRM 20080905 MDOC20082922 WMP Letter*	Industry comment- implementation of water management plans	5/09/08	Letter to Etienne Moller from DRDPIRF

Document	Type	*File name*	Document name	Date	Comment/ Description
	Letter	*MRM 20081005 MDOC20083139 WMP Response Letter*	Implementation of WMPs	5/10/08	letter of support and requested change to reporting of WMP
	Letter	*MRM 20081113 MDOC20083483 Extension Request and Approval*	Submission extension - Annual Environmental Monitoring Report 2005-2008	13/04/08	Grant of extension for submission to MRM
	Letter	*MRM 20081201 MDOC20083637 AER Submission and Acknowledgement Letters*	Annual environmental monitoring report 2005-2008	1/12/08	Acknowledgement of receipt of AER Report
	Letter	*MRM 20081211 MDOC20083725 MMP WQ Amendment Request*	Mining Management Plan Amendment - Sampling Schedule/ analysis	11/12/08	request to alter sampling schedule for GW, SW and Artificial water.
	Letter	*MRM 20090105 MDOC20090025 AER Conditional Approval Letter*	Annual environmental monitoring report 2005-2008	5/01/09	DRDPIFR request for AER Amendment and re-submission.
	Letter	*MRM 20090119 MDOC20090129 AER Company Response and Re-submission*	McArthur River Project - Annual Environmental Monitoring Report	19/01/09	Response to DRDPIFR Comments accompanying AER Re-submission
	Letter	*MRM 20090303 MDOC20090490 AER 2005-2008 Final Assessment*	File Note: Assessment of re-submitted AER	3/03/09	

Document	Type	*File name*	Document name	Date	Comment/ Description
	Letter	*MRM 20090304 MDOC20090489 AER 2005-2008 Approval Letter*	Re: Annual Environmental Monitoring Report 2005-2008	4/03/09	Acceptance letter
	Letter	*MRM 20090311 MDOC20090668 MMP WQ Amendment Request*	Mining Management Plan Amendment - Sampling Schedule/ analysis	11/03/09	Amendment to MMP request from MRM
	Letter	*MRM 20090311 MDOC20090672 AER 2005-2008 Company Response Letter*	Annual environmental monitoring report 2005-2008	11/03/09	Acceptance of AER
	Letter	*MRM 20090402 MDOC20090772 MMP WQ Amendment Approval*	RE: MacArthur River Mine Project - Sampling/ Analysis schedule and temporary storage of concentrate	2/04/09	Response to MRM letter requests of 19/3/2009 and 1/12/2008
	Letter	*MRM 20090408 MDOC20090884 Data Submission Request*	Quarterly submission of water quality data	8/04/09	Letter to MRM detailing new requirement for water quality reporting
Procedures manual - Environmental Monitoring Unit	**Document**	*Procedures Manual*	Procedures manual - Environmental Monitoring Unit	No date	Full manual provided
Project management plan	**Document**	*DRDPIFR 2007_2008 EMU Project Management Plan Excerpt for MRM IM*	DPIFR Project Management plan excerpt	No date	Example of project plan as requested by EES
	Document	*DRDPIFR 2007_2008 EVAL Project Management Plan Excerpt for MRM IM*	DPIFR Project Management plan excerpt	No date	Example of project plan as requested by EES