ENVIRONMENTAL EARTH SCIENCES
THE KNOW AND THE HOW

REPORT NO. **212010**

INDEPENDENT MONITOR AUDIT OF THE MCARTHUR RIVER MINE FOR THE 2011 OPERATIONAL PERIOD

ENVIRONMENTAL EARTH SCIENCES VIC

REPORT TO THE MINISTER FOR MINES AND ENERGY
1 OCTOBER 2012
VERSION 1

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EXECUTIVE SUMMARY

This audit report has been prepared by the Independent Monitor to assess the environmental performance of the McArthur River Mine during the 2011 Operation Period (October 2010 to September 2011). However, it also includes observations made during a mine site inspection carried out by the Independent Monitor team on 28 and 29 May 2012. This is the fifth consecutive annual audit report produced by the Independent Monitor.

The Independent Monitor forms an opinion on the environmental performance of the mining operation through:

- annual site inspections;
- technical review of data and documentation provided to the Independent Monitor;
- discussions with McArthur River Mine and the Department of Mines and Energy (DME);
- MRM's compliance with commitments made in the annual Mining Management Plan; and
- MRM's efforts to improve on environmental performance each year.

Outcome of MRM compliance assessment
As in previous years, MRM have demonstrated a high level of procedural compliance with their commitments made in the 2010/2011 Mining Management Plan (MMP). However, two non-compliances were indentified this audit period. These relate to one prosecution relating to an environmental issue (please note, the prosecution process is yet to be concluded), and the sub aqueous deposition of tailings in the Tailings Storage Facility, rather than sub aerial deposition.

Review of the Department of Mines and Energy
The Department of Mines and Energy (DME) (previously the 'Department of Resources') continues to provide the Independent Monitor with thorough administrative procedures, which the DME uses to assess and regulate the environmental aspects of the MRM operation. Based on the documented evidence provided, the Independent Monitor considers the DME's assessment of MRM's annual Management Plans to be thorough and generally appropriate, however has noted the lag time for approving MMPs as potential issue. The Independent Monitor is pleased to note that the DME have increased the frequency of compliance audits undertaken at the Mine this audit period.

Of particular note this audit period, the DME requested that MRM undertake an assessment of the geotechnical stability of the Tailings Storage Facility (TSF) in response to the Independent Monitor's previous concerns regarding the TSF, as well as an audit of hydrocarbon infrastructure across the mine site. The Independent Monitor commends the DME for requesting these audits from MRM.

Outcome of technical audit
The Independent Monitor has observed many improvements this audit period. MRM continue to demonstrate proactive efforts to improve their environmental performance for many areas of environmental monitoring, and have made efforts to follow up on many of the recommendations made in past Independent Monitor audit reports. The Independent Monitor again considers the following areas of environmental monitoring to be generally appropriate this audit period:

- flora and fauna monitoring both at the mine site and at Bing Bong Port;

- surface water monitoring;
- fluvial sediment monitoring;
- dust monitoring and mitigation at the Mine site;
- structural monitoring of the river diversions; and
- we also note that general reporting has improved for many monitoring programs.

However, there are many more improvements still to be made and many aspects of environmental monitoring are still considered to insufficient to detect and mitigate environmental damage. Key areas of concern this audit period include:

- volume of water stored in Cell 2 of the Tailings Storage Facility (TSF);
- delineation of seepage at the TSF, and its affect on Surprise Creek;
- progress of acidification of the tailings and identification of the treatment options;
- identification and management of Potentially Acid Forming (PAF) rock waste at the Overburden Emplacement Facility (OEF); and
- progress of revegetation on the McArthur River diversion.

Additional areas of monitoring are discussed within the body of this report.

We note that in late 2011, MRM submitted an Environmental Impact Statement (EIS) to the NT Government proposing the 'Phase 3' expansion of the mine. At the time of this report, the Phase 3 EIS was undergoing ministerial review. The $270 million expansion is expected to increase the mine's production to 2036. Although the Phase 3 expansion is outside the scope of this audit period, the potential expansion of the operation is important to bear in mind when considering the environmental outcomes of this report.

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APPENDICES

1 INTRODUCTION

The McArthur River Mine is operated by McArthur River Mining Pty Ltd (MRM), which is 100% owned by Xstrata PLC. The McArthur River Mine is located in the Gulf Region, Northern Territory, approximately 740 kilometres south-east of Darwin and 45 kilometres south-west of the township of Borroloola (Figure 1).

McArthur River Mining has been developing one of the largest known zinc-lead-silver deposits in the world since 1995, when mining was undertaken through underground operations. In 2006, MRM was granted permission to mine using open-cut methods under the 'Phase 2' expansion of the Mine. The site layout is shown in Figure 2 .

1.1 Regulatory and other requirements of this audit

As part of the approval for open-cut mining operations, 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 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 audit activities undertaken by the operator;
  - environmental assessments and monitoring activities undertaken by the Department; and
- report to the Operator and the Department 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 relevant statutory commitments;
- effectiveness of environmental risk management systems;
- occurrence of and response to environmental incidents;
- appropriate and effective monitoring procedures, including air, water, waste, structural, biological and sediment monitoring;
- spatial data management including GIS management, manipulation, representation and presentation of data;
- water management, including: surface water and groundwater modelling; solute transport models; discharge conditions; catchment water balance modelling; 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 (TSF), overburden emplacement facility (OEF), run of mine (ROM) pad, and Bing Bong Port dredge spoil;
- 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; and
- progressive improvements to all of the above.

The Independent Monitor is not required to review mine safety or social issues in the McArthur River region arising from the operation of the Mine.

The timeframe of the audit was focussed on the period from October 2010 to September 2011, which is referred to as the '2011 Operational Period'. It must be noted however, that the audit has also taken into account limited relevant information, data and observations that are more current, as well as observations from the Independent Monitor's mine site inspection undertaken in May 2012.

1.2 Objectives

The objectives of the annual Independent Monitor audit are to:

- review the environmental assessments and monitoring activities undertaken by MRM;
- review environmental assessments and audits undertaken by the DME;
- report to MRM and the DME any urgent issues requiring investigation and reporting; and
- provide an annual audit report to the Minister for Mines and Energy that:
    - assesses the environmental performance of MRM operations; and
    - recommends improvement measures to increase environmental performance.

1.3 Audit scope

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

- review of the MRM monitoring data, management systems, and assessments undertaken during the 2011 Operational Period via:
    - a statutory compliance assessment;
    - a technical review of data and procedures;
    - a site inspection; and
    - interviews with personnel;
- annual update of the Independent Monitor's risk assessment and gap analysis relating to the MRM operation;
- review of environmental audits, assessment, management systems, and environmental monitoring undertaken by the Department of Mines and Energy pertaining to the 2011 Operational Period;
- community consultation and presentations; and
- the provision of this annual report to the Minister for Mines and Energy regarding the environmental performance of the MRM operation.

The following approach has been applied throughout the audit process:

- the Independent Monitor does not collect any data additional to that provided by MRM or the Department of Mines and Energy;
- 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.

Each year, the Independent Monitor selects a number focus areas for technical review. Many of these areas are in response to recommendations for improvement from the previous audit and others are new areas that the Independent Monitor considers to be significant. This audit period, the primary areas of focus included (but were not limited to):

- the performance of the tailings storage facility (TSF) to follow on from the previous audit, particularly in terms of:
  - excess water storage in TSF Cell 2;
  - current and likely future seepage migration from TSF Cell 1 and Cell 2 into Surprise Creek;
  - geochemical assessment/hazard classification of tailings; and
  - effectiveness of the progressive rehabilitation of TSF Cell 1;
- rehabilitation and habitat creation along the river diversions;
- erosion and structural integrity of the river diversion channels;
- hydrocarbon management at the mine site and Bing Bong Port;
- management and monitoring relating to design and function of the Overburden Emplacement Facility (OEF);
- the ongoing performance and of the Bing Bong Port dredge spoil ponds and perimeter drain since the previous audit;
- dust emissions from the Bing Bong Port concentrate storage shed, and the ore-crushing plant area at the Mine site (known as the PACRIM);
- weed management along the river diversion channels and mine site;
- scientific robustness of routine monitoring results collected by MRM;
- issues of environmental concern to the community of Borroloola; and
- the level of detail and quality of reporting of monitoring results.

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 and Bing Bong Port, Northern Territory**

Project: **Independent Monitor 2011 Operational Period**		**Job No: 212010**
Project Man: **LB**	**Scale: As shown**	**Figure 1**
Drawn By: **PF**	Date: **Sept 2012**	

Figure 2 McArthur River Mine (top) and Bing Bong Port (bottom) site layouts in 2011. (Both orthophotos sourced from the 2011 MRM Environmental Monitoring Manual).

2 BACKGROUND

2.1 Relevant legislation and guidelines

The Department of Mines and Energy is the Northern Territory Government agency responsible for mining approvals and compliance. It is the responsibility of the Department of Mines and Energy to administer the requirements of the *Mining Management Act* and Regulations.

The MRM operates under a range of relevant Commonwealth and Northern Territory legislation as listed below:

Commonwealth statutory requirements:

- *Aboriginal Land Rights (NT) Act;*
- *Native Title Act;*
- *Aboriginal and Torres Strait Islander Heritage Act;*
- *Environment Protection and Biodiversity Conservation Act;* and
- *National Environmental Protection Measures.*

Northern Territory Statutory requirements:

- *Environment Assessment Act;*
- *Environment Assessment Act;*
- *Aboriginal Sacred Sites Act;*
- *Weeds Management Act;*
- *Water Act;*
- *Heritage Conservation Act;*
- *Pastoral Land Act;*
- *Waste Management and Pollution Control Act;*
- *NT Lands Act;*
- *Bushfires Act;*
- *Petroleum Act;*
- *Native Title Act;*
- *Public Health Act;*
- *Territory Parks and Wildlife Conservation Act;*
- *Soil Conservation and Land Utilisation Act;*
- *Energy Pipelines Act;* and
- *Traffic Act.*

2.2 Overview of previous Independent Monitor audits

The Independent Monitor has conducted four previous audits. This report presents the findings of the fifth consecutive Independent Monitor audit of the environmental performance of the mining operation. Environmental Earth Sciences has been leading the Independent Monitoring team over the past five years of auditing, and this audit is the last to be undertaken for the 5-year contract. As such, the next Independent Monitor audit in 2013 may be undertaken by a different team of auditors.

The Independent Monitor has completed four previous audits of MRM's environmental performance 2007, 2008, 2009, and 2010 Operational Periods. MRM have made significant improvements to their environmental performance over this time, however many significant environmental issues still remain to be addressed. Significant findings from the previous Independent Monitor audits are summarised in the sections below.

All previous Independent Monitor reports are available for download from:

www.mrmindependentmonitor.com.au

2.2.1 2007 Operational Period audit

This audit was undertaken in 2008 and focussed on the environmental performance of MRM for the 2007 Operational Period. It included a technical review of environmental management and monitoring practices as well as a compliance audit compared with operating conditions.

Results of the audit indicated 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 and several incomplete conformances were noted.

In the technical review of MRM's monitoring and reporting for the review period, the Independent Monitor found considerable data gaps as well as a general inadequacy of interpretation of monitoring results both by MRM, and external consultants.

Several monitoring programs were recommended for improvement and/or rectification over the subsequent three to five years. These were:

- improved monitoring, 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 Port load-out facility;
- improvement of dust management practices, particularly at the tailing storage facility;
- improved management and rehabilitation of the Bing Bong Port dredge spoil dump; and
- adjustments to analytical suites for the surface water and groundwater monitoring programs.

2.2.2 2008 Operational Period Audit

In 2009, the Independent Monitor completed an audit of the environmental performance of MRM over the 2008 Operational Period. During this audit, some improvements from the 2007 Operational Period audit were noted, however, the Independent Monitor identified two significant issues that urgently required immediate investigation and reporting. These issues were:

- tailings leachate migration from TSF Cell 1 into Surprise Creek; and
- saline leachate from the Bing Bong Port dredge spoil affecting vegetation surrounding the spoil ponds.

MRM subsequently took action to bring these issues under more control. Regarding the TSF Cell 1 leachate, a leachate collection sump was installed and further monitoring and investigations were proposed. Regarding the Bing Bong dredge spoils, an outer spoon drain was constructed around the dredge spoil ponds to redirect saline seepage out to sea. It was noted that these issues would still require further investigation, monitoring and ongoing mitigation.

Other less urgent but still significant issues were:

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

2.2.3 2009 Operational Period audit

The Independent Monitor audit of the 2009 Operational Period was undertaken in 2010, with a site inspection being conducted in May 2010.

In 2010 it was found that a number of issues identified in the previous audit report had since been addressed by MRM, however, a number of ongoing issues were found to remain, with additional issues also being identified. These included:

- excess water storage in TSF Cell 2, which the Independent Monitor considered to pose a significant risk of overtopping and embankment failure due to spillways being under-designed for a flood event;
- seepage migration from the TSF to Surprise Creek and the hazard classification of tailings in Cell 1 and Cell 2;
- fugitive dust emissions from the mine site ROM (‘run of mine’) pad/ PACRIM ore-crushing area at the mine site;
- fugitive dust emissions from the Bing Bong Port concentrate storage shed;
- detail and quality of reporting of the dust, soil and sediments monitoring program and inclusion of long term trends and base studies;
- weed management along the river diversion channels and the mine site;
- structural integrity of the Bing Bong dredge spoil ponds; and
- testing of the TSF Cell 1 clay cap to ensure it meets design specifications.

2.2.4 2010 Operational Period audit

In 2011, the Independent Monitor assessed the environmental performance of the MRM operation over the '2010 Operation Period'. Many improvements were noted through this audit and the following monitoring programs were considered to be generally adequate:

- flora and fauna monitoring both at the mine site and at Bing Bong Port;
- surface water monitoring;
- fluvial sediment monitoring; and
- structural monitoring of the river diversions.

However, significant issues of concern were also identified. These included:

- adverse impacts of seepage from the TSF have been detected in Surprise Creek;
- dust from operations at the ROM pad and PACRIM crushing plant, and also historically from the TSF expressed in stream sediments in both Barney Creek and Surprise Creek;
- volume of water stored in Cell 2 of the TSF remained a concern as the Independent Monitor considered there to be an extreme risk of embankment failure or overtopping of the spillway;
- visual method for classification of NAF/PAF waste rock was of concern as it was considered to pose the potential for misclassification;
- progress of acidification of the tailings and delineation of the treatment options;
- generation of fugitive dust emissions from the PACRIM area, and, to a lesser extent, the Bing Bong Port concentrate storage shed;
- structural integrity of the Bing Bong Port dredge spoil pond walls;
- slow progress of revegetation on the McArthur River diversion; and
- inadequacy of reporting of many routine monitoring programs.

These issues have been followed up by the Independent Monitor this audit period, and are reported throughout Section 9 of this report.

3 AUDIT METHODOLOGY

This audit has been conducted in accordance with the Independent Monitoring Assessment Conditions (IMACs) (2006) and the Scope of Services for the Independent Monitor's contract of engagement, as agreed between the Independent Monitor and the Department of Mines and Energy.

The full list of documents reviewed this audit period for MRM and the Department of Mines and Energy are provided in Appendices D and E respectively.

3.1.1 Independent Monitor team

The Independent Monitor team is lead by Environmental Earth Sciences and is supported by technical consultancy from Low Ecological Services, Bewsher Consulting, and Knight Piésold. The roles of Independent Monitor team members are outlined in Table 1.

TABLE 1 INDEPENDENT MONITOR TEAM

Name	Company	Position title	Area of audit focus	Years of industry experience
Philip Mulvey	Environmental Earth Sciences	Senior Principal Scientist	IM Audit Team Leader. Mine waste geochemistry, hydrogeology, soils, sediment and dust	32
Mark Stuckey	Environmental Earth Sciences	Principal Hydrogeologist and Soil Scientist	Groundwater and surface water.	17
Don Still	Bewsher Consulting	Principal Hydrologist	River diversion and surface water hydrology	35
Theo Gerritsen	Knight Piésold	Senior Geotechnical Engineer	Geotechnical issues	14
Dr Bill Low	Low Ecological Services	Principal Ecologist	Flora and fauna	51
Nicola Hanrahan	Low Ecological Services	Environmental Scientist	Flora and fauna	1
Holger Woyt	Low Ecological Services	Marine ecologist	Marine flora and fauna	22
Laura Boland	Environmental Earth Sciences	Environmental Scientist	IM Project Manager. Environmental Management Systems	5
Jorge Alcaino	Environmental Earth Sciences	Environmental Scientist	Seawater, sediments, soil and dust	5

Note: IM = Independent Monitor.

3.2 Site inspection

The Independent Monitor undertook a mine site inspection over two days: 28 and 29 May 2012. As part of the inspection, the Independent Monitor inspected the MRM operation of the:

- Tailings Storage Facility;
- Bing Bong Port facility and dredge spoil pond;
- Northern Overburden Emplacement Facility;
- Plant nursery;
- ROM pad and PACRIM (crushing plant);
- mine site workshop and storage area;
- hydrocarbon storage areas; and
- Barney Creek and McArthur River diversion channels and rehabilitation efforts.

3.3 Personnel interviewed

McArthur River Mining personnel were interviewed during the mine site inspection. Gary Taylor, MRM Health Safety and Environment Manager, was the primary point of contact for the Independent Monitor during the audit. Other MRM personnel interviewed during the site inspection included:

- Julie Crawford – Environmental Superintendent;
- Sam Strohmayr – Metallurgical Manager;
- Karissa Grenfell – Mining Manager; and
- Mike Williams – Administration Manager.

On 31 May 2012, Mark Stuckey and Laura Boland from the Independent Monitor team met with the following personnel from the Department of Mines and Energy to discuss the DME's processes and procedures used for the assessment of the McArthur River Mine operation:

- Russell Ball – Director Mining Performance;
- Mitchell Rider – Executive Officer Mining Projects;
- Michael Fogg – Environmental Scientist, Mining Environmental Compliance;
- Gary Martin – Team Leader, Mining Team;
- Graham Williams – Team Leader, Technical Support; and
- Tony Scherer – Mining Officer.

4 RISK ASSESSMENT UPDATE

4.1 Purpose, objectives and scope of risk assessment

Each year the Independent Monitor undertakes an annual risk assessment to fulfil a requirement set out in the Independent Monitor Scope of Services, to assess environmental risks associated with the MRM operation. This year the risk assessment was updated based on the technical review of monitoring data from the 2011 Operational Period and observations made during the May 2012 mine site inspection. The objectives of the risk assessment were to:

- identify environmental risks associated with MRM operations, which are considered significant in the opinion of the Independent Monitor team; and
- evaluate whether environmental monitoring and assessment practices undertaken by MRM are adequate and appropriate to mitigate the risk of potential environmental impacts.

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

Based on the adequacy and effectiveness of MRM's environmental monitoring systems, and their effectiveness in monitoring these issues, risks of potential environmental impacts resulting from the mine site and Bing Bong Port operations, were examined and evaluated, for the following monitoring areas:

- Tailings Storage Facility (TSF);
- McArthur River and Barney Creek diversions;
- the management of surface water, artificial waters and groundwater;
- the Overburden Emplacement Facility (OEF);
- Bing Bong Port dredge spoil;
- Dust emissions at the Mine site and Bing Bong Port; and
- flora and fauna monitoring and management.

Scope of information input
Information was generally limited to the 2011 Operational Period; however observations made during the May 2012 site inspection and more recent information was also considered during the risk assessment, so the scope of the risk assessment comprised all information provided to the Independent Monitor for this audit period.

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

4.2 Stakeholders

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

- the community of Borroloola;
- Traditional Owners;
- the general public;
- future generations;
- McArthur River Mining Pty Ltd; and
- the Department of Mines and Energy.

4.3 Methodology

In general, the risk assessment was undertaken in accordance with the methodology advised within ISO 31000:2009 – Risk Management Principals and Guidelines (Standards Australia, 2009).

Assumptions and exclusions as discussed in Section 1.3 apply to the risk assessment methodology.

4.3.1 Risk identification and analysis

Together with their own expert knowledge and experience, the Independent Monitor team used the following information resources to identify potential environmental risks:

- documentation provided by MRM;
- documentation provided by the Department of Mines and Energy;
- annual Dry Season mine site inspections undertaken by the Independent Monitor from 2008 - 2012; and
- interviews with MRM personnel during site inspections, and interviews with DME personnel during a meeting in Darwin in May 2012.

Each team member identified and systematically listed environmental risks relating to their area of expertise (for example, flora and fauna). Other aspects considered and recorded in the risk register include:

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

4.3.2 Risk evaluation

Risk evaluation was conducted on the basis of residual risk with known controls in place. Consequently, the risk rating derived is based upon the information sources provided to the Independent Monitor by MRM.

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

risk = consequence + likelihood

'Consequence' was determined to be the reasonable maximum impact there may be on the environment if existing monitoring and assessment controls were inadequate or inappropriate. This consequence was considered with regard to both the location and duration of the impact (see Tables in Appendix A).

The reasonable consequence and likelihood of occurrence was considered for each impact in terms of the scales provided in the risk matrix and the results of the risk assessment are recorded in the risk register along with the risk matrix in Appendix A.

4.4 Outcomes of risk assessment

As recorded in the risk register in Appendix A (Table 20), a total of 70 environmental hazard items were assessed for risk by the Independent Monitor this audit period. These items are summarised below.

This risk assessment should be reviewed and updated by the Independent Monitor again as part of the next audit in 2013.

4.4.1 Extreme risks

In the last audit period there were **2 extreme** risks identified by the Independent Monitor, which were considered to pose extreme environmental risk. This audit, the same extreme risks have again been assessed and remain unchanged in their risk rating. These risks relate to:

- overtopping of TSF cells leading to an embankment failure; and
- the potential for acid leachate migration from the TSF into Surprise Creek.

The Independent Monitor has provided undated comments regarding these two items, which are provide in Table 20 in Appendix A. The Independent Monitor recommends that MRM undertake immediate mitigation works to reduce the risk of these hazards occurring.

4.4.2 High risks

Last audit 18 high risks were identified by the Independent Monitor. This audit **13 high** risk items were assessed. The more significant **high** risk issues (those with a risk matrix result of 4 rather than 5) are associated with the TSF, and include:

- Dry Season discharge of seepage containing salt, and metals enters Surprise Creek and causes flora die back and/ or bioaccumulation of metals in flora.;
- Wet Season discharge of seepage containing acid, and metals enters Surprise Creek and causes flora die back and/ or bioaccumulation of metals in flora.;
- TSF Cell 2 embankment fails - Stability failure; and
- TSF Cell 2 Embankment failure due to scouring at toe of embankment.

See the tables in Appendix A for the full list of **high** risk items.

4.4.3 Moderate risks

In the last audit period, a total of 43 risks were identified as moderate, this year, **36** risks were considered to have a **moderate** risk rating. These can be viewed in Table 20 in Appendix A.

The Independent Monitor is pleased to see a decrease in the number of moderate risks identified this audit. While one new risk was identified this year, all moderate risks have either remained unchanged from the previous year, or have been downgraded since the last audit.

4.4.4 Low risks

In the last audit 8 low risks were identified and in this audit **19 low** risks were identified. Many of these Low risks have been downgraded since the previous Independent Monitor audit, which is a positive outcome for the environmental performance of the mining operation.

The environmental issues associated with the hazards listed in the Risk Register (Appendix A, Table 20) are discussed within the relevant sections of the technical review (Section 9).

5 GAP ANALYSIS

5.1 Gap analysis overview

Assumptions and exclusions detailed in section 1.3 apply to this gap analysis, which is undertaken annually as a requirement of the Independent Monitor Scope of Services. Its purpose is to identify gaps that require improvement in environmental monitoring and assessment undertaken for MRM operations and it is updated by during each audit period.

Included is a comparison of the environmental performance of MRM with:

- best practice industry standards such as the *Leading Practice Sustainable Development Program for the Mining Industry*;
- expert assessment and recommendations; and
- MRM statutory obligations.

Each member of the Independent Monitor team separately identified monitoring and assessment gaps in their field of expertise.

5.2 Gap identification and assessment

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'.

Gaps that were identified are listed in the gap register in Appendix B.

5.3 Gap evaluation

To maintain a consistent and systematic methodology between Independent Monitor team members, each identified gap was evaluated in accordance with the *Gap analysis process flow chart*—developed by Environmental Earth Sciences and included in Appendix B—and used to categorise identified gaps as described in Table 2.

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

TABLE 2 GAP EVALUATION CATEGORIES

Gap Category	Description
Category 1	Monitoring to mitigate potential associated environmental risk is not undertaken.
Category 2	Monitoring is undertaken, but is not sufficient in design – i.e: frequency, location, type and so on, are insufficient to identify or quantify potential environmental risks.
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 risks.

5.4 Outcomes of gap analysis

In the last audit the Independent Monitor identified a total of 18 'Category 1' gaps, 16 'Category 2' and five 'Category 3' gaps.

This year, the Independent Monitor has identified:

- 17 Category 1 gaps;
- 15 Category 2 gaps; and
- 8 Category 3 gaps.

These gaps are detailed in the gap register in Appendix B and are reflected in the comments made in the technical review in Section 9.

5.5 Recommended actions

The Independent Monitor recommends that the monitoring or reporting measures suggested in the gap register be actioned by MRM, and/or relevant reporting be provided to the Independent Monitor during the next audit period to demonstrate how the gaps will be addressed or how they have been closed.

As part of the next audit, the gap register should be reviewed and updated in light of the corrective measures undertaken by MRM.

6 REVIEW OF MRM'S ENVIRONMENTAL COMMITMENTS

6.1 Update from Previous Audit

Last audit period the Independent Monitor reviewed 103 commitments relating to environmental performance in the 2009/2010 MMP and made the following observations:

- 71 commitments were found to be compliant;
- due to the limited time for site inspections and lack of provision of documentation, 22 commitments were not able to be verified by the Independent Monitor this audit, however many of these were considered to be likely compliances; and
- one non-compliance was related to the following commitment:
  "Prior to capping the tailings, the post-mining tailings surface topography will be reformed to minimize erosion".

On-site clay cover was observed by the Independent Monitor on May 2011 and, through conversations with staff, it was determined that the cover—placed at 0.5 m thick—had not undergone reshaping, and was acting as a dust suppression measure only. Additionally, some erosion was observed. In May 2012, the Independent Monitor team observed that MRM were working to resolve this issue as shaping was being undertaken through the use of a grader.

6.2 Review of MRMs compliance with 2010/2011 MMP

MRM have again displayed a high level of compliance with the environmental commitments in the MMP 2010/2011, however we note that a high procedural compliance alone does not equate to good environmental performance, but it is used as one measure.

This audit period, the Independent Monitor has reviewed 81 environmental commitments, A total of 12 commitments could not be verified through the information available to the Independent Monitor this audit, 6 commitments were partially compliant, and 61 commitments were found to be compliant, and identified two non-compliances with MMP commitments:

- *'No environmental fines, penalties or prosecutions'.* The IM is aware of a prosecution involving an environmental incident regarding the May 2011 hydrocarbon spill at the Mine site. Please note that the prosecution process is currently underway, and had not been concluded at the time of this report; and
- *'The tailings will be deposited sub-aerially in thin layers to maximise the density of the tailings beach against the embankment, providing a low permeability beach of tailings between the decant water pond and the perimeter embankment'.* In both the 2011 and 2012 site inspections, the Independent Monitor observed tailings being deposited aqueously. See Plate 1 below. However, we note that sub-aerial deposition occurs once the tailings beach has risen above the spigot height.

The list of commitments assessed by the Independent Monitor is provided in Appendix C.

Plate 1 Aqueous deposition of tailings observed by the IM during the May 2011 site inspection.

6.3 Review of the 2011/2012 MMP and WMP

The Independent Monitor is pleased to note an increase in the level of reporting and detail provided in the annual Mining Management Plan (MMP) this audit period. Similarly, the level of reporting, presentation and discussion presented within the annual Water Management Plan (WMP) (which is part of the MMP process) has also improved greatly on previous editions of this document. We commend both MRM and the DME for their successful efforts to improve the quality of these documents. However, the IM has made further recommendations for further improvement in reporting, which are detailed within Section 9 of this report, and should be incorporated into future MMP and WMP reports.

7 REVIEW OF THE DME'S MONITORING OF MRM

7.1 Overview and purpose

The Independent Monitor conducted a review of the internal processes and procedures used by the Department of Mines and Energy (DME) to regulate MRM's environmental performance under the NT *Mining Management Act* and Regulations. This review was undertaken through an evaluation of documents submitted to the Independent Monitor (see Appendix F for list of documents), and through a meeting with DME staff on 31 May 2012.

7.2 Update from last audit

Last audit period, the DME provided the Independent Monitor with administrative procedures and other documentation used in the regulation of the MRM operation. The Independent Monitor considered these procedures and assessments undertaken by the DME to be thorough and technically appropriate. The recommendations in Table 3 were made following the Independent Monitor's review. Note that due to the retrospective nature of the

Independent Monitor's annual audit, actions resulting from the Independent Monitor's recommendations given in 2011 will not be reviewed through audit until 2013.

TABLE 3 UPDATE ON RECOMMENDATIONS FROM PREVIOUS AUDIT

Recommendation last audit	Update this Audit
Increased detail in reporting, including outcomes of discussions, statements of which industry standards the operation is being compared to, the reasons for inspecting certain areas at certain times and so on.	The DME agreed that the detail of their site inspection reports could be increased.
The monitoring areas examined in audits should be rotated in subsequent audits. It is further recommended that some members of staff be rotated for each audit so that different areas of staff expertise can be applied to subsequent audits of the MRM operation. The DME may already do this; however the IM has only reviewed two audits, so it is unclear. Some overlap of staff between audits will also be required to ensure consistency.	The DME has acknowledged the IM's recommendation.
Discuss with MRM the possibility of attaching separate detailed reports to the MMP to provide greater detail regarding the status of environmental monitoring at the MRM.	The DME agreed that this could be a possibility and would be worthwhile to increase the detail of MRM's environmental monitoring reporting. The IM has noted an improvement in the detail of reporting by MRM within the 2011/2012 MMP and WMP.
As part of future check-monitoring reporting, the EMU personnel should include the items outlined in section 7.3 of the IM's Audit Report for the 2010 Operational Period, which were missing from the Water Quality Field Report reviewed.	The 2011 annual check monitoring program was undertaken in May 2011, prior to the release of the IM's 2010 Operational Period Audit Report (in October 2011). Therefore, the recommendations regarding check- monitoring and reporting could not be incorporated in the 2011 check-monitoring report. However, DME will consider these recommendations in future check monitoring programs.

7.3 Review of audits and assessments undertaken by the DME for the 2011 Operational Period

The Department of Resource have continued to improve in the quality and volume of documents and data provided to the Independent Monitor each year. This audit period, the DME provided the IM with a well-organised set of documents, assessments, audits and procedures produced by the DME in their regulation the McArthur River Mine. These documents are reviewed in the following sections.

7.3.1 2010 Compliance Audit

The DME provided the following audit and assessment reports to the Independent Monitor for review:

- 2010 Compliance Audit – *2009/10 Mining Management Plan Compliance Audit 13 to 16 December 2010 Audit Report*;
- 2010 Compliance Audit – *Field Inspection Report,* Dated 17 December 2010*;* and
- related correspondence between MRM and the DME.

2010 Compliance Audit Report

The above reports were reviewed by the Independent Monitor as part of the previous Independent Monitor audit undertaken in 2011. However, the timing of the DME's audit falls within the 2011 Operational Period. Please refer to the Independent Monitor's report for the 2010 Operational Period for a review of this compliance Audit.

Field Inspection Report

The 2010 *Field Inspection Report* was prepared in December 2010, and we note this report was also reviewed as part of the previous Independent Monitor Audit conducted in 2011.

The purpose of the 2010 field inspection was to *"Conduct MMP and WMP audit follow up on previous audit findings and inspect reported salt deposits on rocks under the Surprise Creek Bridge on the Carpentaria Highway*". (p.1). We note that the Field Inspection Report only appears to comment on salt accumulation in Surprise Cree rather than the other audit items, and it is unclear whether these items are addressed in another report. Nevertheless, regarding salt accumulation along Surprise Creek, the DME's inspection team did not observe any significant salt accumulation at this location at the time of inspection. MRM already monitor surface water at this location and will continue this monitoring through water sampling and visual monitoring for salt build up. The Independent Monitor considers this action to be appropriate.

7.3.2 2011 Compliance Audit

The Independent Monitor has reviewed reports and documentation relating to the DME's 2011 Compliance Audit of MRM, including:

- 2011 Compliance Audit – *2010/11 Mining Management Plan Compliance Audit,7 – 8 December 2011 Audit Report;*
- 2011 Compliance Audit – *Field Inspection Report*, 3 February 2012; and
- related correspondence between MRM and the DME.

2011 Audit Report

The 2011 Audit Report has also improved in the detail of reporting compared with previous audit reports. We also note this Audit Report represents an increase in the frequency of compliance audits undertaken by the DME at MRM, which the Independent Monitor considers to be a valuable exercise.

The DME has provided comprehensive comments against MMP Commitments from the 2010/2011 MMP as evidence of MRM's statutory compliance. The Independent Monitor understands that the list of commitments included in the Audit does not include all commitments of the 2010/2011 MMP. However the reasons for selecting the chosen commitments for audit does not appear to be documented within the report. The Independent Monitor recommends that this aspect be documented within future audit reports. This was also a recommendation from the previous Independent Monitor Audit.

As a minor comment, the Independent Monitor disagrees with the statement in the 2011 Audit Report that environmental management of the McArthur River Mine is of a 'high standard'. This statement covers many aspects of environmental management of the Mine that the Independent Monitor has considered to be significantly deficient in previous years. As recommended last audit, it would be beneficial for the DME to reference the 'best practice principals' against which MRM is being measured. An example may include: Leading Practice Sustainable Development Program for the Mining Industry (Australian Government

Department of Mines and Energy, Energy and Tourism, 2009). Without identifying any specific best practice principals, MRM's environmental performance cannot be consistently measured or compared in this way.

2011 Field Inspection report

The *Field Inspection Report* documented the site visit to MRM undertaken by Gary Martin of the DME on 3 February 2012. The purpose of the inspection was to:

- observe the Aburri Barge loading procedures to assess the potential for concentrate spillage;
- inspect an area where a diesel spill occurred at Bing Bong Port on 21 December 2011 (reported as a serious or critical incident to the DME – See Table 5); and
- Follow up on a dam safety review of the TSF and adjacent Water Management Dam (WMD), which was requested by the DME.

The Independent Monitor considers the Inspection Report to provide adequate detail of the site inspection conversations, observations and required follow up. In this respect, the 2011 Inspection Report has improved on previous inspection reports reviewed by the Independent Monitor. The inclusion of specific questions posed to MRM regarding the Bing Bong diesel spill are also a valuable addition to the report this year.

7.3.3 DME annual assessment of MMP and WMP

The Department of Mines and Energy annually assesses the Mining Management Plan and Water Management Plan submitted by MRM each year. The Independent Monitor has reviewed correspondence and reports relating to the assessment of the 2010/11 and 2011/2012 MMP, and 2010/2011 and 2011/2012 WMP. The following observations are noted.

2010/2011 MMP assessment and approval

- 2010/2011 MMP received on 12 November 2010;
- The DME provided MRM with a comprehensive list of comments and questions relating to the MMP on 11 March 2011;
- MRM provided the DME with a letter response to comments on 6 May, after requesting an extension for the delivery of comments;
- MRM submitted three separate amendments to the 2010/2011 MMP, which included the following requests:
    - 18 July 2011 – Amendment to the drilling program at the mine site including the addition of two drill holes, which would require the establishment of an access track. No further correspondence from MRM or the DME has been provided;
    - 30 August 2011 – Investigation of water inflows into the mine pit through injection of a tracer liquid into groundwater. MRM's request letter provided incomplete information regarding the nature of the tracer and method of investigation. The DME requested appropriate additional information from MRM to fill information gaps. The amendment was subsequently approved by DME on 9 September 2011; and

- 16 September 2011 – Topsoil storage relocation at the OEF. The DME again requested additional information from MRM to assess drainage lines and how long stock piles will be stored. MRM's response has not been provided to the Independent Monitor, and thus cannot be reviewed.

2011/2012 MMP assessment and approval

- The 2011/2012 MMP was submitted to DME on 9 November 2011. DME provided MRM with comments and requests for additional information on 20 March 2012;
- additional information requested by the DME appears are considered appropriate and comprehensive; and
- MRM were directed to address the comments within 30 days. MRM responded on 2 May 2012.

2010/2011 WMP assessment and approval

- MRM submitted the 2010/2011 WMP on 30 August 2010;
- the DME requested that additional information be submitted as per letter request 20 September 2010. The comments and requests for further information indicate a thorough assessment of the WMP by the DME;
- the WMP was subsequently updated and comments were appropriately addressed by MRM; and
- correspondence relating to six amendments to the 2010/2011 WMP was provided to the Independent Monitor for reviewed. These included:
  - 12 November 2010 – Implementation of six evaporative fans at the TSF in preparation for the 2010/2011 Wet Season on a 12 month trial basis. The DME requested an evaluation report regarding the fans' effectiveness, following the 12-month trial. This report was not provided to the Independent Monitor for review;
  - 2 February 2011 – Proposal to discharge water from the Water Management Dam (WMD) (adjacent to TSF Cell 2). Correspondence between the DME and MRM has been reviewed by the Independent Monitor, and is considered adequate in detail and content. The DME granted MRM conditional approval of this amendment on 18 February 2011;
  - 1 March 2011 – the Independent Monitor reviewed email correspondence between MRM and DME for the short-term utilization of an evaporative fan at Bing Bong to reduce surface water. The DME directed that summary of the use of the fan at this location was to be included in the 2011/2012 WMP. In the 2011/2012 MMP, MRM did note that the fans were used for three weeks, but were turned off several times due to unfavourable weather. The effectiveness of the fans was not discussed;
  - 10 March 2011 – Secondary strategy for discharge of uncontaminated water from the WMD into Barney Creek during the Wet Season;
  - 24 March 2011 – request to increase the discharge rate of surface water collected in the old McArthur River (within the mine levee wall) to the McArthur River; and

- 18 April 2011 – MRM request to section an area of the WMD to store more contaminated water from Pete's Pond, and prevent mixing with cleaner water already in the WMD. No response from the DME was provided for review.

2010/2011 WMP assessment and approval

- The 2011/2012 WMP was provided to the DME for assessment on 30 September 2011;
- the DME provided extensive comments and request for information from MRM regarding the 2011/2012 WMP, which indicate a thorough review of the Plan, and a strong commitment to the technical efficacy of water management at the Mine. The Independent Monitor considers the level of detail in the DME's requests for information to be appropriate; and
- the Independent Monitor has reviewed correspondence which indicates that although timelines of delivery were extended, these revised timelines were agreed and adhered to.

Overall, the Independent Monitor considers the quality of the assessment and approval process of WMPs and MMPs to be appropriate. However we note that there is a lag time between receiving the MMP and providing assessment and final approval to MRM, which takes between 5 to 9 months (including response times from MRM). The Independent Monitor should investigate this time lag next audit.

7.3.4 Hydrocarbon Audit

On 28 June 2011, the DME requested that MRM undertake an audit of hydrocarbon storages at the mine site. The request was submitted in response to recent environmental incidents involving hydrocarbons spills, which were reported to the DME (see Table 5). We note that the DME made effort to ensure the timely delivery of this audit from MRM.

The Independent Monitor's review of the hydrocarbon audit report is provided in Section 9.2.7.

7.3.5 Stability of Tailings Storage Facility

The Independent Monitor has reviewed a letter from the DME to MRM (dated 15 December 2011) requesting a geotechnical assessment of the TSF embankments. The Independent Monitor commends the DME for following up on this issue, which has been highlighted by the Independent Monitor previously as a significant issue of environmental concern.

The geotechnical assessment works were scheduled to be completed throughout April and May 2012 and will be reviewed as part of the next Independent Monitor audit to be completed in 2013.

7.3.6 Review of the DME's check monitoring

The Independent Monitor has previously reviewed the DME's procedures and manuals for undertaking check-monitoring of surface water and groundwater, which the Independent Monitor considered to be comprehensive and appropriate.

This Audit period the Independent Monitor as reviewed the *Department of Mines and Energy Environmental Monitoring Unit's (EMU) Field Report, McArthur River Mine 2011,* and associated chemical data. Comments on the monitoring are provided as follows:

- it is strongly recommended that DME EMU analyse for pH and TDS in the laboratory so that field and transportation QC can be more rigorous, as per the following discussion:
    - field and laboratory determined pH values need to be compared (through calculation of their relative percent differences [RPDs]). The results of this assessment need to be reported for quality control (QC) purposes, with discussion of any results where the RPD is >10%;
    - the laboratory determined TDS and field determined EC ratio needs to be calculated for all samples (acceptable TDS/EC range of 0.55-0.80), with results reported as part of the QC discussion and any results outside the acceptable range discussed; and
    - RPD between field collected blind (intra-laboratory) duplicate samples and split (inter-laboratory) duplicate samples (if collected), including presentation and discussion of results and elevations in RPDs in particular;
- it is recommended that a full cation and anion ionic balance be undertaken on all samples, which in addition to the current analysis for sodium (Na), calcium (Ca), magnesium (Mg), potassium (K), chloride (Cl), sulfate (SO_4) and bicarbonate (HCO_3), should also include ammonia (NH_3-N), nitrate (NO_3), nitrite (NO_2), phosphate (PO_4) and fluoride (F). The commercial laboratory undertaking the testing should be able to add these analytes to the existing suite. Once expanded, this suite will allow a more comprehensive assessment of site hydrogeochemistry (at each location over time, and demarcation of groundwaters across the site into chemical categories), as well as assessment of QC by determination of the charge balance equation (CBE) between cations and anions;
- given that the lower shale member that reports as NAF to the Overburden Emplacement Facility (OEF) is enriched with selenium (Se), it would be beneficial for Se to be considered to establish background levels and monitor the impact from the OEF;
- dissolved Al results for the pH range measured strongly suggest an error with filtration of samples prior to acid preservation:
    - Al is insoluble in the pH range of 5.5-8.5, and as Figure 3 below demonstrates, this is not the case for the 2011 DME EMU data-set. Therefore sample collection, filtration and preservation practises for dissolved metals analysis require assessment and review;
    - if collected samples are field filtered (as is noted in the report), it is recommended that duplicate samples be collected unpreserved and sent to the laboratory for filtration and subsequent preservation, in order to compare data;
    - it is considered likely that the problem relates to attempts to filter turbid samples, which seems to be supported by Figure 4 and Figure 5 below, which shows that a relationship exists between turbidity and dissolved Al. Hence, in addition to filtering in the laboratory (all the better if this is a mobile site laboratory), samples can be placed on a bench and the suspended sediment allowed to settle, then a sample of supernatant subsequently obtained from the top of the sample bottle for filtration; and

- o the fact that turbid groundwater samples are being collected also raises questions about both bore construction and sampling methodology – if details on these could be provided for review, comment can be made;

- as DME EMU have been undertaking sampling for 10 years, it is recommended that a data-base be set up for each sampling location over time for all analytes, as only pH and EC data is presented in the report (it is assumed this has been undertaken, but has not been seen by this reviewer);
- no alkalinity/acidity/total acidity results were provided—it is understood that these are normally done in the field by the EMU, but they have not been provided in the report; and
- the Independent Monitor concurs with DME EMU 2011 report recommendations for surface water and groundwater.

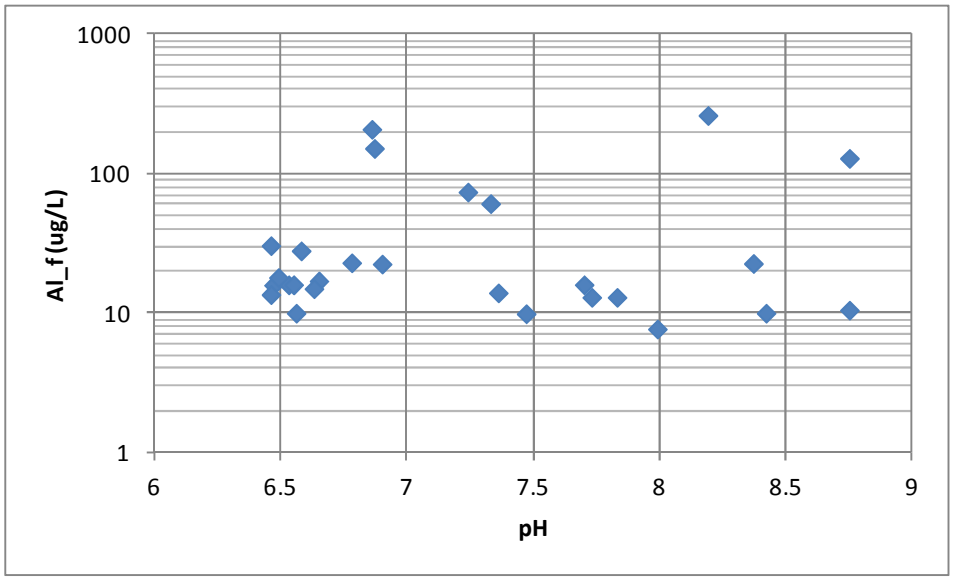


Figure 3 Relationship between dissolved Al and pH, DME EMU 2011 sampling (note logarithmic scale on y-axis)

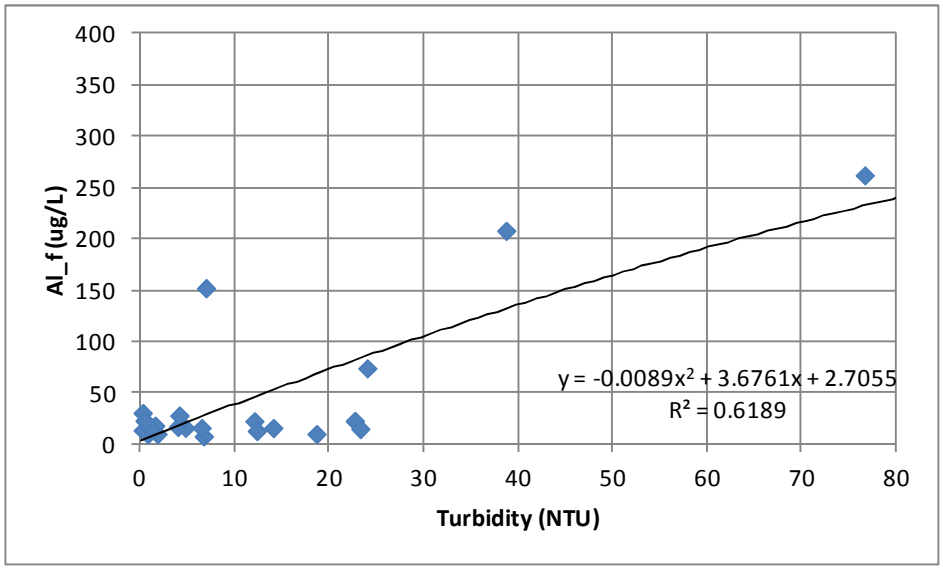


Figure 4 Relationship between dissolved Al and turbidity, DME EMU 2011 sampling

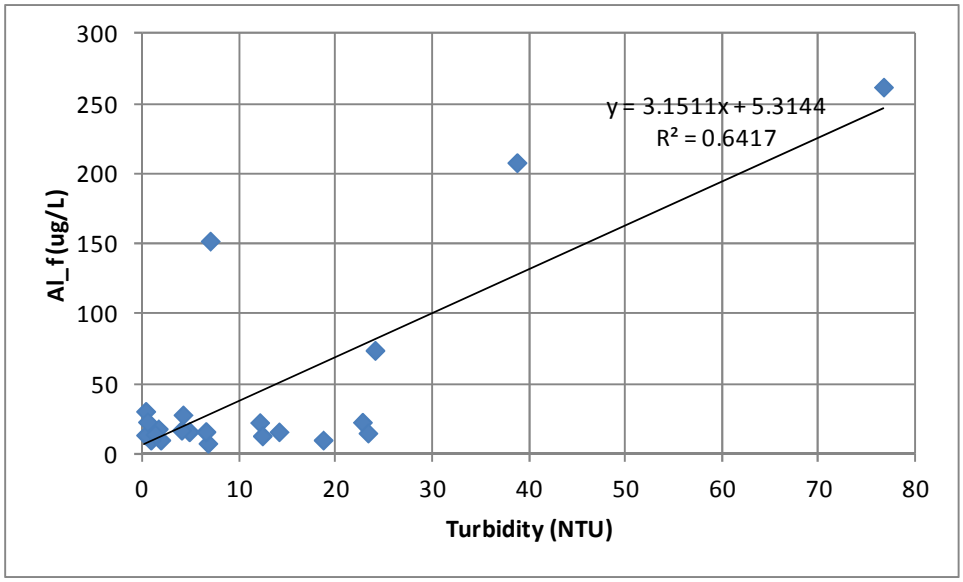


Figure 5 Relationship between dissolved Al and turbidity, DME EMU 2011 sampling (outlier removed)

7.3.7 Summary of recommendations

The general recommendations for groundwater and surface water monitoring include:

- quality assurance and control (QA/QC) needs to be improved by determination of:
  - TDS/EC ratio (acceptable range of 0.55-0.80);
  - field pH to laboratory pH relative percent differences (RPDs), with an acceptable RPD of 10%;
  - RPD between field collected blind (intra-laboratory) duplicate samples and split (inter-laboratory) duplicate samples (if collected), including presentation and discussion of results and elevations in RPDs in particular;
- analytical suite:
  - analysis for metals and metalloids be limited to dissolved species including dissolved Al, Fe, Mn and Se;
  - a full cation and anion ionic balance be undertaken on all samples (pH, TDS, Na, Ca, Mg, K, Cl, SO_4, HCO_3, NH_3, NO_3, NO_2, PO_4 and F); and
- the Independent Monitor concurs with DME EMU 2011 report recommendations for surface water and groundwater.

8 ENVIRONMENTAL INCIDENTS

8.1 Incidents reported during the 2011 Operational Period

The Independent Monitor has reviewed environmental incident reports for incidents that occurred over the 2011 Operational Period. Environmental Incidents, which are minor in nature are handled internally within MRM, however incidents of a serious or critical nature are reported to the DME.

The Xstrata environmental incident category ranking system is provided in Table 4.

TABLE 4 XSTRATA ENVIRONMENTAL INCIDENT CATEGORY

Xstrata incident categories		
Category 1	Negligible	Causes negligible, reversible environmental impact, requiring very minor or no remediation
Category 2	Minor	Causes minor, reversible environmental impact, requiring minor remediation
Category 3	Moderate	Causes moderate, reversible environmental impact with short-term effect, requiring moderate remediation
Category 4	Serious	Causes serious environmental impact, with medium-term effect, requiring significant remediation
Category 5	Disastrous	Causes disastrous environmental impact, with long-term effect, requiring major remediation

Table 5 below, lists the Environmental Incidents reported to the DME during the 2011 Operational Period. Note that the incidents outlined in Table 5 were not given an incident ranking anywhere on the incident reports provided to the Independent Monitor.

TABLE 5 SERIOUS OR CRITICAL ENVIRONMENTAL INCIDENTS REPORTED TO THE DEPARTMENT OF MINES AND ENERGY

Date of incident	Incident Notification details	IM Comment
3/05/2011	Seepage from the north eastern are of the NOEF first occurred in June 2010. A sump was constructed to collect the seepage. This sump overflowed on May 2011 due to inadequate design, allowing the uncontrolled flow of seepage down a natural drainage line.	The IM has reviewed an Incident Investigation Report prepared by MRM. The report appropriately details the causes of the incident., however, the following information is not included in the report: - Flow rates or volumes of seepage are not provided in the report; - It is unclear how far the water travelled or whether it reached any fresh water streams; and - While laboratory analysis of seepage is provided, MRM have not provided any comment on the potential ecological impacts of this incident.
Reported as '4/05/2010', However, date should be 2011.	Seepage observed from the Northern Side of the NOEF, which was not reporting to the previously constructed sump and drain. The seepage flowed down a naturally occurring drainage line towards the North East of the OEF.	It is unclear from the Incident Notification form as to whether this seepage has occurred from the toe of the OEF, or from the Sump collecting the overflow (as above). MRM is advised to accurately describe the nature of the incident to avoid ambiguity and confusion. MRM should update the Incident report to provide the correct date to ensure records kept are accurate.
19/05/2011	Diesel leak occurred from a valve in the vicinity of the Power Plant Yard at the mine site. Approximately 27,000L was spilt in the vicinity and has impacted local groundwater. The incident occurred as the valve was left unlocked, and is presumed to have been knocked open by passing cattle.	MRM is currently involved in litigation over this issue, which has been initiated by the Northern Territory Government. A full review of MRM's response to this incident is provided in Section 9.2.7.
4/11/2012	Leak of approx 5,500L of contaminated water from Pete's Pond leaked from pipes, some of which entered Barney Creek.	An Incident Investigation Report has been reviewed by the IM. The Report appropriately details the causes of the pipe failure (failure of previous repair works) and the sampling of water in Barney Creek downstream of the impact. Laboratory results of water analysis are provided, however there is no comment or assessment from MRM regarding the potential environmental impacts of this incident.
21/12/2011	Approximately 2,000L of diesel overflow from a Bing Bong storage tank due to the failure of a float level shut-off switch within the tank. Product was mainly contained within the bunded area, but some product also observed in the BBSRP. Product was captured and placed into IBCs.	The Incident Investigation Report appears to be comprehensive in the identification of causes for the incident, and identifies appropriate mitigation strategies to prevent a similar incident in future. However, no comment on the likely environmental impact is provided. Although the IM considers the potential impact to be low, as the majority of the product reportedly drained to the Bing Bong Surface Runoff Pond (BBSRP), where it was collected, or was contained within the bunded area surrounding the tank.
31/12/2011	Overflow of the interception spoon drain outside the NOEF during heavy rain. Overflow water flowed down a natural drainage line. A sump was subsequently to an existing sump where it was pumped to the NOEF PAF Dam	The Incident Investigation Report adequately outlined the causes of the incident, and the response actions appear to be appropriate. However, the results of water analysis are poorly presented and are not fully legible in the report. Further, no interpretation of potential environmental impacts is provided in the report.

Note: NOEF = North Overburden Emplacement Facility.

The following internal environmental incidents occurred over the Operational Period.

TABLE 6 ENVIRONMENTAL INCIDENTS REPORTED INTERNALLY AT MRM

Date of incident	Xstrata incident category	Incident details	IM Comment
29/06/2011	Cat. 3	TS1 bore (GW67) destroyed by bulldozer due to the expansion of the mine pit. No further action was required or undertaken.	MRM Should ensure that groundwater bores in the vicinity of planned earth works are appropriately decommissioned prior to the commencement of earthworks in the area.
8/09/2011	Cat. 1	Burst hydraulic hose of a truck causing fluid leak along the driving path of the truck along haul roads between the mine pit and NOEF.	The IM considers response to be appropriate.
13/09/2011	Not rated	Wallaby killed by vehicle	The IM considers response to be appropriate.
30/01/2011	Cat. 1	Exceedance of Aluminium concentrations in surface water at discharge point.	MRM attributed the elevated levels to upstream sources and no further action was undertaken. The IM considers response to be appropriate.
7/02/2012	Cat. 1	Waste oil spill from punctured IBC - around 200L	The IM considers response to be appropriate.
12/01/2012	Cat. 1	Elevated sulfate concentrations	The IM considers response to be appropriate.
29/02/2012	Cat. 1	Elevated sulfate concentrations	The IM considers response to be appropriate.

8.2 Recommendations for incident reporting and investigation

Following the review of the environmental incidents outlined in Table 5 and Table 6, the Independent Monitor makes the following comments:

- it would be useful for MRM to provide an overview of environmental incidents that occurred onsite during the reportable period within the MMP, as these incidents form aspect of the environmental performance of MRM and should be mentioned;
- in future, it would be useful for MRM to notify the Independent Monitor of any recent serious or critical environmental incidents that have occurred prior to the Independent Monitor's annual site inspection; even if the incident falls outside the Operational Period under review at the time. The purpose of this notification would for the Independent Monitor to inspect the impact (where possible) to:

- provide contemporaneous assessment of the appropriateness of MRM's monitoring and remediation response;
- focus the Independent Monitor audit on the monitoring area (e.g. hydrocarbon storage) that has failed as part of the incident, so that any further issues can be identified and mitigated; and
- provide an up-to-date overview of MRM's environmental performance within the Independent Monitor's public reports.

9 OUTCOMES OF TECHNICAL AUDIT

9.1 Review of surface water and artificial water monitoring

Surface water and artificial water are monitored periodically at the locations at the McArthur River mine site provided as shown in Figure 6 and Figure 7 below. The following documents have been reviewed as part of the surface water component of the Independent Monitor's audit for 2011-2012:

- MRM P/L *Sustainable Development Mining Management Plan (MMP) 2011/2012*, dated September 2011;
- MRM P/L *Sustainable Development Water Management Plan (WMP) 2011/2012*, dated August 2011, in particular Sections 3.8, 4.0, 6.2 and 6.4;
- WRM Water + Environment *McArthur River Mine Phase 3 Development Project Surface Water Assessment*, dated January 2012; and
- data sets and field reports (i.e. Excel spreadsheets, copies of completed field monitoring records, etc).

Figure 6 MRM natural surface water monitoring sites (Figure source: 2011/2012 WMP)

9.1.1 Mine site surface water and artificial water monitoring

In Section 4.1 of the 2011/2012 WMP, MRM has identified the following limited list of sources of risk to surface water quality at the mine site:

- potentially acid forming (PAF) waste rock;
- depositional dust; and
- contaminated process water.

The Independent Monitor agrees that these are risks; however, the list is incomplete. It should be noted that due to the nature of the mine expansion—that is new TSF cells, river diversions, civil works and so on, as well as general operational risks—the existence of *all* potential sources of detrimental impact to surface water quality should be identified, regardless of their risk. An example of this is the first point pertaining to impacts from PAF waste rock.

Figure 7 MRM artificial surface water monitoring sites (Figure Source: 2011/2012 WMP)

It has recently been demonstrated that the current and near-term impacts on surface water quality are those of "neutral mine drainage (NMD)", that is, increased salinity and the presence of sulfosalts, rather than that of acidic drainage. Notwithstanding the fact that it has not yet been demonstrated acid mine drainage (AMD) will not occur in the future.

The TSF is of particular concern to surrounding surface water system(s) due to the extent of leakage that is occurring. This has been acknowledged in Section 4.1.3 of the 2011/2012 WMP, in the discussion of contaminated process water. The 2011/2012 WMP states that "to mitigate…prolonged discharge into Surprise Creek" due to artificial water table mounding from TSF leakage "MRM has implemented" a number of control measures. The Independent Monitor considers these measures to be appropriate.

As described in Section 4.6 of the WMP, monitoring of the natural surface water in upstream and receiving water environments of Barney Creek, Surprise Creek and McArthur River is undertaken to:

- continually improve the knowledge and characterisation of natural water quality and variation in upstream and receiving water environments;
- assess and monitor potential contaminant impacts of mine operations, including mine water management impacts, and groundwater impacts on surface water quality; and
- supplement the fluvial sediment monitoring program.

Under the natural surface water monitoring program (which monitors 24 locations and is therefore described as intensive) triggers levels have been set, and any breach of triggers is investigated and mitigated if necessary. This program is considered by the Independent Monitor to be appropriate, and the 2011/2012 reporting period has demonstrated improvement in monitoring, management and reporting.

With regards to the artificial monitoring points, an additional two locations have been recommended on the northern and eastern sides of the OEF (see recommendations in Section 1.1.3 below). It is noted that WRM (2012) recommend that these locations (as well as the north-eastern side of the OEF) have sediment dams constructed (Figure 7.1, p37) and that the northern OEF surface water area be included in the natural surface water monitoring program (Figure 11.1, p 117).

9.1.2 Bing Bong surface water and artificial water monitoring

The Independent Monitor also considers (based on the May 2012 site inspection) that surface water management at the Bing Bong port facility has been improved significantly from the previous review. This is due primarily to:

- the significant increase in surface water run-off storage capacity through the addition of a third surface water runoff pond;
- construction of the concentrate storage shed water monitoring and discharge system (Plate 3 b); and
- maintenance of the dredge spoil pond perimeter bunding, including a geotechnical testing program using a Cone Penetration Test (CPT) method (Plate 3 a).

Plate 2 A third surface water runoff pond has been installed since 2011. This additional storage pond increases MRM's capacity to store potentially contaminated surface runoff water at the Bing Bong Port facility through the Wet Season.

a.

b.

Plate 3 Bing Bong surface water management improvements: **a**) geotechnical testing of the Bing Bong dredge spoil walls to gain an understanding of the material makeup of the walls, and thus, the potential for saline seepage through the walls; and **b**) tanks have been installed around the Bing Bong concentrate storage shed to capture clean rain water and divert it to sea, rather than to onsite storage during the Wet Season.

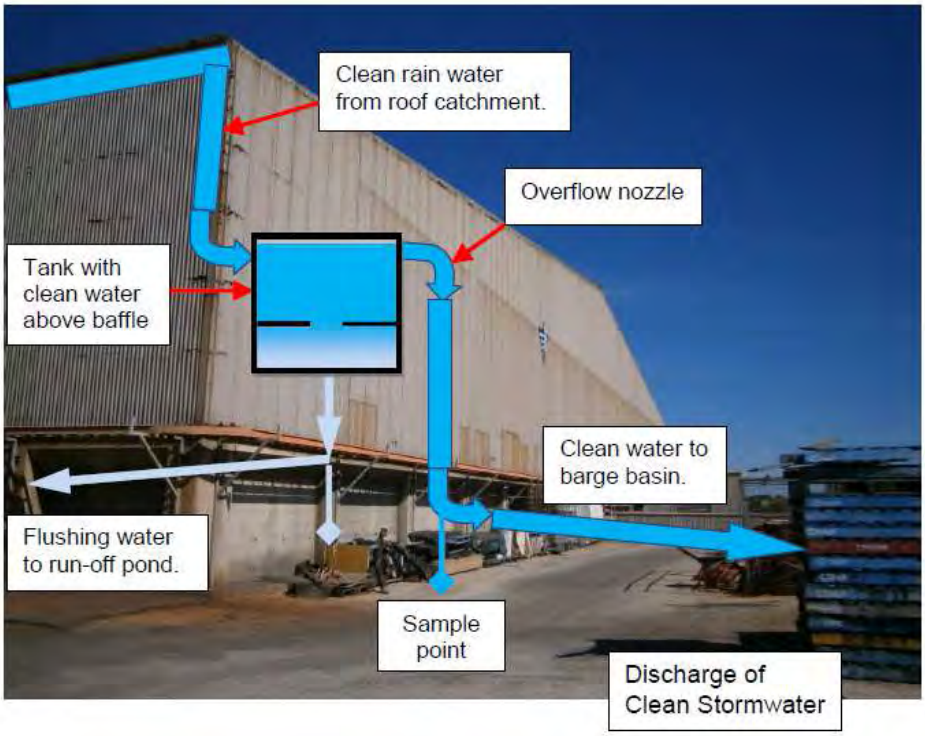


Figure 8 Schematic diagram showing the functioning of the roof capture system pictured above in Plate 3 b, above. (Figure sourced from 2011/2012WMP).

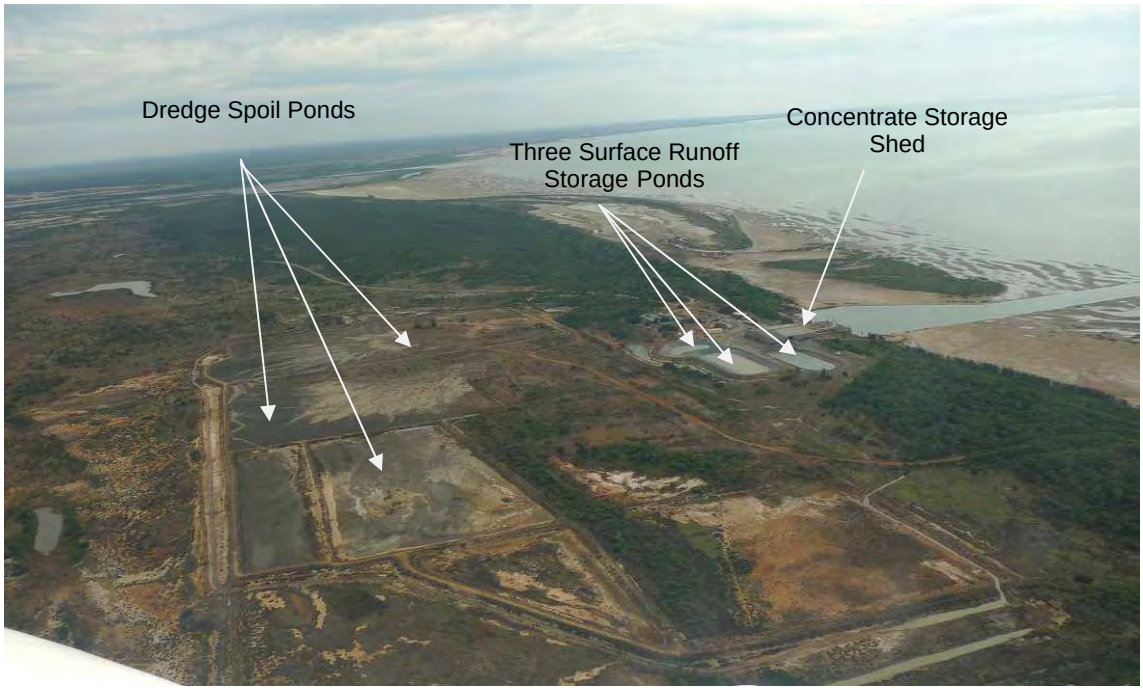


Plate 4 Aerial view of the Bong Bong Port Facility, showing the three surface water runoff ponds, dregde spoil ponds, and concentrate storage shed.

9.1.3 Surface water monitoring recommendations

Overall, the Independent Monitor concurs with the discussion and presentation of natural surface and artificial water monitoring provided in the WMP. The following are observations and recommendations arising from the review of the 2011/2012 WMP:

- as with the 2009/2010 reporting period recommendations, adjustments to the surface water monitoring program should be implemented by adding sampling points on the drainage line where the seepage from the Northern OEF was reported. In addition, the seepage observed from the western toe of the OEF during the May 2012 inspection should also be included in the monitoring program for surface waters; and
- quality assurance and control (QA/QC) reporting presentation has improved with the inclusion of TDS/ EC and field/ lab pH plots for each sampling location. However, as described in previous Independent Monitor reports, a discussion on the quality, precision, accuracy and reproducibility of results is an essential component of water monitoring. Aspects of the QA/QC reporting should include comparison of field to laboratory results, in particular:
    - TDS/EC ratio (acceptable range of 0.55-0.80);
    - field pH to laboratory pH relative percent differences (RPDs), with an acceptable RPD of 10%;
    - RPD between field collected blind (intra-laboratory) duplicate samples and split (inter-laboratory) duplicate samples, including presentation and discussion of results and elevations in RPDs in particular; and
    - discussion of findings of the laboratory's quality control reporting.

The above results of QA/QC assessment between field and laboratory data should be discussed in the WMP, in particular instances where comparisons of field and laboratory data fall outside of acceptable ranges.

9.2 Review of groundwater monitoring and management

The following documents have been reviewed as part of the groundwater component of the Independent Monitor's audit for 2011-2012:

- MRM P/L *Sustainable Development Mining Management Plan (MMP) 2011/2012*, dated September 2011;
- MRM P/L *Sustainable Development Water Management Plan (WMP) 2011/2012*, dated August 2011, in particular Sections 3.5, 3.6.17.5, 3.6.18, 3.6.19, 3.6.20, 4.1.1, 4.3.6, 5.0 and 6.3;
- MRM P/L *McArthur River Mine 2011 Diesel Spill, Detailed Site Investigation and Remediation Action Plan*, dated 14 March 2012;
- MRM P/L *McArthur River Mining Pty Ltd – Audit of Hydrocarbon Infrastructure*, letter to NT Department of Mines and Energy dated 20 October 2011;
- URS Australia P/L *EM Survey – TSF Monitoring Program, McArthur River Mine*, dated 21 February 2011;
- URS Australia P/L *TSF EM34 Geophysical Surveillance Survey, McArthur River Mine*, dated 4 April 2012;

- URS Australia P/L *Report – MRM Phase 3 Development Project EIS – Groundwater*, dated 16 January 2012;
- Golder Associates *Hydrogeochemical Investigation of the Tailings Storage Facility, McArthur River Mine prepared for MRM P/L*, report 107633048-003-Rev0, dated 17 June 2011; and
- data sets and field reports (i.e. Excel spreadsheets, copies of completed field monitoring records, etc).

Other documents cited in this section are:

- Australian and New Zealand Environment and Conservation Council (ANZECC)/ Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy;
- ANZECC (1992) *Australian water quality guidelines for fresh and marine waters*. National Water Quality Management Strategy;
- Friebel, E & Nadebaum, P (2011) *Health screening levels for petroleum hydrocarbons in soil and groundwater. Summary*, CRC CARE Technical Report no. 10, CRC for Contamination Assessment and Remediation of the Environment, Adelaide, Australia;
- Hickey, C (2002) *Nitrate guidelines in ANZECC 2000*. Memorandum dated 30 September 2002. National Institute of Water & Atmospheric Research Ltd, NZ;
- National Health and Medical Research Council (NHMRC)/ Natural Resource Management Ministerial Council (NRMMC) (2011) *Australian drinking water guidelines*. National Water Quality Management Strategy; and
- NHMRC/ NRMMC (2008) *Guidelines for managing risks in recreational water*. Australian Government, February 2008.

Groundwater monitoring locations for water quality are presented in Figure 9 Figure 10 below.

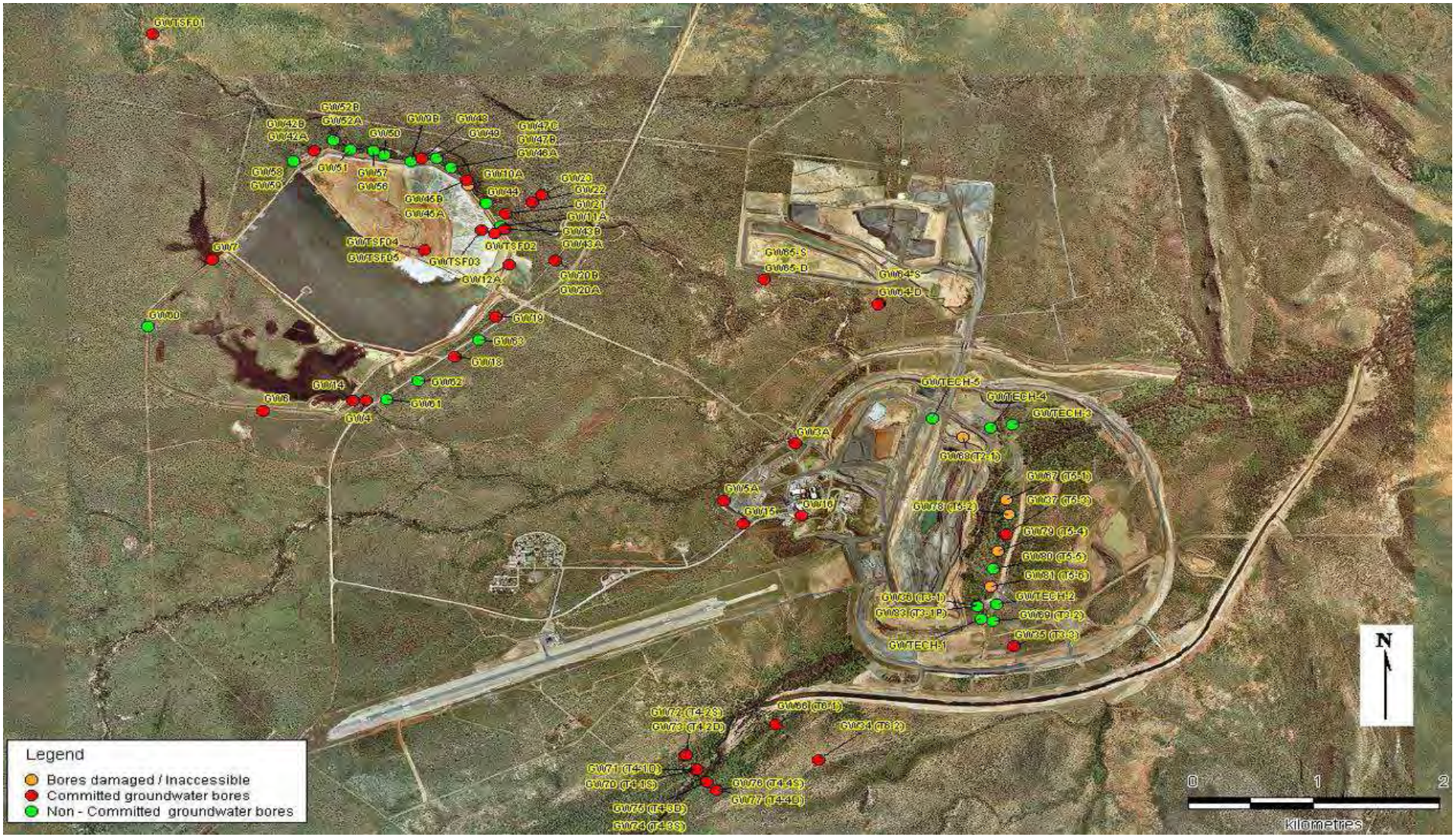


Figure 9 MRM groundwater quality sampling locations (Figure source: 2011/2012 WMP)

Figure 10 Bing Bong groundwater quality sampling locations (Figure source: 2011/2012 WMP)

9.2.1 Groundwater management and monitoring program overview

As stated in the MRM 2011/2012 WMP, the objectives of MRM's groundwater management program are to:

- monitor the impacts of groundwater abstraction;
- determine the impacts of any contaminants in shallow aquifers;
- assess the effectiveness of TSF seepage control systems; and
- assess potential impact of the establishment of the northern OEF.

Of the above four objectives, the first relates to physical (as well as potentially chemical) data collection, interpretation and reporting, whilst the remaining three relate to assessment of potential chemical impacts on aquifers beneath the site and potential receptors (e.g. Surprise Creek). As such, a discussion will follow that separates aspects of the Independent Monitors review on the basis of physical and chemical data collection and interpretation/ presentation.

The MRM 2011/2012 WMP (refer to Section 5.1) has identified potential sources of pollution to groundwater at the site as:

- potentially acid forming (PAF) waste rock;
- hydrocarbons; and
- contaminated process water (in particular the TSF).

The Independent Monitor agrees with this assessment. In addition, the MMP (Section 2.4.1) contains a background discussion groundwater occurrence at the site and surrounds that is also adequate. If information is lacking in the reports supplied, this relates to "impacts of groundwater abstraction", for which an assessment of collected data (in particular hydrographs of relevant bores compared to recharge influences such as rainfall, and discharge influences such as abstraction volumes and pumping rates and times for all bores and sumps) is recommended. This is discussed further below.

9.2.2 Overview of physical monitoring (in particular groundwater abstraction impacts)

The MRM 2011/2012 WMP indicates that there are three bore fields operating to supply groundwater to the site (Section 3.5: MIMEX, Emu and Donkey bore fields). Abstracted groundwater, following treatment, is used as part of ore processing (reagent mixing and gland water top-up), for human consumption, and fire suppression. The report states that groundwater usage is monitored via flow meters that are monitored monthly, with the data collected used to monitor trends and update water balance monitoring.

The Independent Monitor recommends (if this is not already undertaken and the data has simply not been observed by the Independent Monitor) that in addition to the above data interpretation, some data assessment of groundwater usage and consequent aquifer drawdown's about individual bores be undertaken. This should include (but not be limited to):

- monitoring water levels in abstraction and surrounding observation bores prior to, during, and following cessation of pumping cycles (installation of pressure transducer data-loggers in at least some wells would be advantageous);
- constructing hydrographs of pressure levels in all abstraction bores and nearby observation bores, including rainfall and abstraction volumes and rates; and
- assessing data such as recovery rates following cessation of pumping and drawdown rates during constant discharge.

This will allow direct assessment of "the impacts of groundwater abstraction" on the aquifer/s from which these bore fields are withdrawing. It is suggested (as indicated above) that the use of pressure transducer data-loggers, to supplement manual dipping, would be useful (and cost-effective) as part of bore field water level monitoring. The assessment works are likely to include determination of aquifer physical parameters such as transmissivity, storativity/ specific yield, and sustainable yield, as well as the extent of depressurization and rates and extent of recovery following cessation of pumping.

The above recommendations are considered to support those of Coffey Geotechnics *Draft groundwater review* dated 29 September 2010, which was reviewed as part of the previous Independent Monitor report (Environmental Earth Sciences 2011, Section 9.2.3).

In addition to groundwater abstraction for water supply from bore fields, dewatering bores are also utilised about the pit (see WMP Sections 3.6.18, 3.6.19 and 3.6.20). The management of these bores and the water abstracted from them, as described in the WMP, is considered appropriate, in particular the diversion of 'clean' water before it discharges to the pit.

9.2.3 Overview of water quality (chemical) monitoring

The MRM 2011/2012 WMP (Sections 4.1.1, 5.1 and 5.1.1) correctly identifies the Overburden Emplacement Facility (OEF) as a potential source of groundwater contamination. It is considered by the Independent Monitor that the OEF will have a major influence on the underlying groundwater due to the weight of the facility increasing the pressure on aquifer pore spaces, and hence increasing hydraulic pressure beneath the facility. This will likely have the result that hydraulic gradients, and hence groundwater velocity, will be increased radially away from the OEF. This likely occurrence is particularly important to the south of the OEF. As such, this is likely to be increasing groundwater discharge to Surprise Creek.

Any such occurrence should be able to be picked up by monitoring static water levels (SWLs) over time in monitoring bores GW64S, GW64D, GW65S and GW65D, as well as water chemistry in these bores and in Barney Creek monitoring points SW2, SW24, SW18 and SW19. It is recommended (as it is for all bores for which SWL is measured) that hydrographs be constructed for monitoring bores GW64S, GW64D, GW65S and GW65D to allow assessment of changes in groundwater pressure over time.

It is also considered by the Independent Monitor that there is a potential for recharge of OEF seepage to groundwater, particularly in areas where seepage is significant and allowed to accumulate as surface standing water. Such is the case at the northern and eastern toes of the OEF, hence it is recommended that the installation of nested monitoring bores (as with GW64 and GW65) be considered in these areas. Nested bores will allow assessment of vertical hydraulic gradients, and any changes in vertical gradients over time, in addition to chemical assessment for potential surface recharge/ seepage and associated pollution.

Hydrocarbons are a major potential source of groundwater pollution at the mine site, due primarily to the large volumes stored and used on the site. This fact has recently been highlighted following the May 2011 diesel spill. The Independent Monitor has:

- reviewed the MRM (2012) DSI and RAP (see Section 9.2.6 below);
- undertaken a review of hydrocarbon audit documentation (also see 9.2.7 below); and
- whilst on-site, inspected hydrocarbon storage facilities and the May 2011 spill site.

Recommendations of the Independent Monitor relating to managing potential impacts of hydrocarbons on groundwater are detailed in Sections 9.2.6 and 9.2.7 below. Please note that an error occurs regarding discussion of total petroleum hydrocarbon (TPH) results in Section 6.3.7 of the 2011/2012 WMP. Surrogate recovery percentages for 1,2-dichloroethane, toluene and 4-bromofluorobenzene (which are undertaken by laboratories as part of their QC processes) were discussed as though they were 'real' results for bore GW3A. These chemicals are 'artificially' spiked and their recoveries measured in the laboratory; they are not present in groundwater and do not require discussion.

Most groundwater monitoring bores at the site that are utilised for water quality monitoring are in the vicinity of the TSF, in particular between Cell 1 and Surprise Creek (see Figure 9 above and Table 6.8, p 174 of the 2011/2012 WMP). It is obvious from an inspection of the area between TSF Cell 1 and Surprise Creek that there is a major issue with the discharge of saline groundwater in this area. The Independent Monitor commends MRM for the efforts

that have been undertaken to date (and continue to be undertaken) to investigate, manage and mitigate this issue. Further discussion is provided in Section 9.2.5 below.

The results of groundwater monitoring at the Bing Bong port facility are discussed in the MRM 2011/2012 WMP, which is reviewed in the following section of this report.

9.2.4 Overview of groundwater management

Section 5.2 of the MRM 2011/2012 WMP details the groundwater management program that has been developed at the site. The Independent Monitor has reviewed this (along with the URS report – see the IMs 2011 review report, Section 9.2.2), and makes the following comments.

All of the work conducted to date on groundwater management has been very focussed on physical aspects such as flow modelling, drilling, dewatering and inflow management (in short, monitoring the impacts of groundwater abstraction at the pit). As discussed above (Section 9.2.2), more focus is recommended to be placed on physical monitoring of bore fields and developing hydrographs, as well as looking at physical and chemical influences over time for all monitoring bores across the mine site and port (Section 9.2.3).

9.2.5 Review of MRM 2011/2012 WMP Groundwater Quality Monitoring

This review has concentrated on Section 6.3 of the WMP, which details the results of groundwater quality monitoring at the site (and port) over 2011/2012. The following points are noted:

- the following comments are made on the analytical suite adopted:
    - field readings need to include pH so that field and laboratory determined pH values can be compared (through calculation of their relative percent differences [RPDs]). The results of this assessment need to be reported for quality control (QC) purposes, with discussion of any results where the RPD is >10%;
    - as for surface water, the laboratory determined TDS and field determined EC ratio needs to be calculated for all samples (acceptable TDS/EC range of 0.55-0.80), with results reported as part of the QC discussion and any results outside the acceptable range discussed;
    - it is recommended that analysis for metals be limited to dissolved species and that analysis for 'total' metals cease, however that dissolved aluminium (Al), iron (Fe) and manganese (Mn) be added to the dissolved metals suite. This will allow a more thorough assessment of the potential for false positives in the dissolved metals analysis, as well as redox processes and degree of microbial activity in groundwater (and hence potential natural attenuation and biodegradation processes); and
    - it is recommended that a full cation and anion ionic balance be undertaken on all samples, which in addition to the current analysis for sodium (Na), calcium (Ca), magnesium (Mg), potassium (K), chloride (Cl), sulfate (SO_4) and bicarbonate (HCO_3), should also include ammonia (NH_3-N), nitrate (NO_3), nitrite (NO_2), phosphate (PO_4) and fluoride (F). The commercial laboratory undertaking the current testing (e.g. ALS Brisbane) should be able to add these analytes to the existing suite at minimal additional cost. Once expanded, this suite will allow a more comprehensive assessment of site hydrogeochemistry (at each location over time, and demarcation of groundwaters across the site into chemical categories), as well as assessment of QC by determination of the charge balance equation (CBE) between cations and anions;

- the following comments are made on the analytical results observed for the 2011 monitoring period for bores about the mine process area:
    - GW5A contains elevated arsenic (As) and zinc (Zn). These values do not appear to be replicated in the nearest surface water sampling points in Barney Creek (SW3 and SW22), however GW15 is also slightly elevated in these metals. These trends should continue to be monitored in future rounds;
    - Section 6.3.5.3 of the 2011/2012 WMP lists a criteria for As of 500 µg/L based on NEPC (1999), which is in turn based on ANZECC (1992) for livestock drinking quality. It is suggested by the Independent Monitor that this guideline value should be replaced by more relevant values for fresh water ecosystems based on ANZECC/ ARMCANZ (2000) of 24 µg/L or human contact based on NHMRC/ NRMMC (2011 and 2008) of 70 µg/L;
    - in addition to the above, it is considered by the Independent Monitor that a general reconsideration of groundwater quality criteria is warranted as NEPC (1999) and ANZECC (1992) are not considered entirely appropriate (or other more recent criteria are considered more relevant). As such, Table 7 has been presented as an outline of recommended values based on potential receptors to groundwater discharge or usage;
    - the discussion in Section 6.3.5.3 of the WMP seems to incorrectly state maximum, mean and median levels of all metals (As, Cu, Cd, Zn and Pb) for the mine process area, which appear to have been significantly under-estimated. For example, As is present up to 25 µg/L in GW5A (Figure 6-29), Pb up to 50 µg/L in GW15, Zn up to 1,080 µg/L in GW5A, Cd up to 2.5 µg/L in GW5A and Cu up to 35 µg/L in GW16 (Figure 6-30);
    - GW3A contains relatively elevated sulfate (SO_4), with a downward trend in Cl/SO_4 ratio (i.e. the relative concentration of SO_4 is increasing over time). This location should continue to be assessed for chemical trends over time; and
    - it is noted that Figure 6-31 (p184) presents charts of comparison of field pH and EC with laboratory determined pH and TDS, however the results should be discussed from a QC perspective in the discussion text, in particular any deviations from expected ranges. Generally speaking, alkalinity seems to increase in sample transit to the laboratory and this should be discussed based on the results obtained;
- the following comments are made on the analytical results observed for the 2011 monitoring period for bores about the OEF:
    - sulfate (SO_4) is elevated in GW64D and GW65D in particular, whilst the Cl/SO_4 ratio is also rapidly declining in GW64S (see Chart 1 below), suggesting that influences of neutral mine drainage may be apparent in these bores, with the relative influence of SO_4 on groundwater anion chemistry increasing over time (see Figure 11 below);
- the following comments are made on the analytical results observed for the 2011 monitoring period for bores about the TSF:
    - sulfate (SO_4) is particularly elevated (>1,000 mg/L) at bores GW4, GW14, GW18, GW19, GW12A (>5,000 mg/L), GW20A, GW20B, GW43A, GW43B (>5,000 mg/L), GW21, GW22, GW42B, GW45B (>5,000 mg/L) and GW48 (>5,000 mg/L), which also correlate to the locations with lowest Cl/SO_4 ratios; and
    - long term trends of elevated dissolved Zn are apparent in GW14, GW4, GW20A, GW43B and GW22.

TABLE 7 RECOMMENDED WATER QUALITY CRITERIA FOR GROUNDWATER

Criteria	pH	Al	As	Cu	Cd	Fe	Mn	Pb	Zn
Ecological	6.5-7.5	**0.055**	**0.024**	**0.0014**[1]	**0.0002**[1]	**NE**	**1.9**	**0.0034**[1]	**0.008**[1]
Health	6.5-8.5	0.2[#]	0.007	2	0.002	0.3[#]	0.1[#]/0.5	0.01	3.0
Recreation	**6.5-8.5**	NE	**0.07**	20	0.02	NE	5.0	0.1	30
Livestock	NE	5.0	0.5	0.5	0.01	NE	NE	0.1	20

Criteria	TDS	Na	Ca	NH_3	Cl	SO_4	NO_3	NO_2	F
Ecological	NE	NE	NE	**0.9***	NE	NE	**31.9**[3]	NE	NE
Health	1000[#]	180[#]	NE	0.5[#]	250[#]	500	50	3	1.5
Recreation	NE	**NE**	NE	NE	**NE**	5000	500	**30**	15
Livestock	**5000^**	NE	**1000**	NE	NE	**1000**	400	30	**2.0**

Notes:

1. need to be adjusted for hardness according to ANZECC/ ARMCANZ (2000); NE no criteria exist; bold values indicate potential most relevant criteria;
2. all table entries in mg/L except pH; ^ beef cattle assumed; # aesthetic only hence no recreational criteria;
3. value derived after Hickey (2002); NH4-N x 1.29 = NH4; NH3-N x 1.21 = NH3; NO2-N x 3.3 = NO2; NO3-N x 4.43 = NO3;
4. * adjust for pH based on Table 8.3.7 of ANZECC/ ARMCANZ (2000); and
5. increasing temporal concentration trends should also act as a trigger.

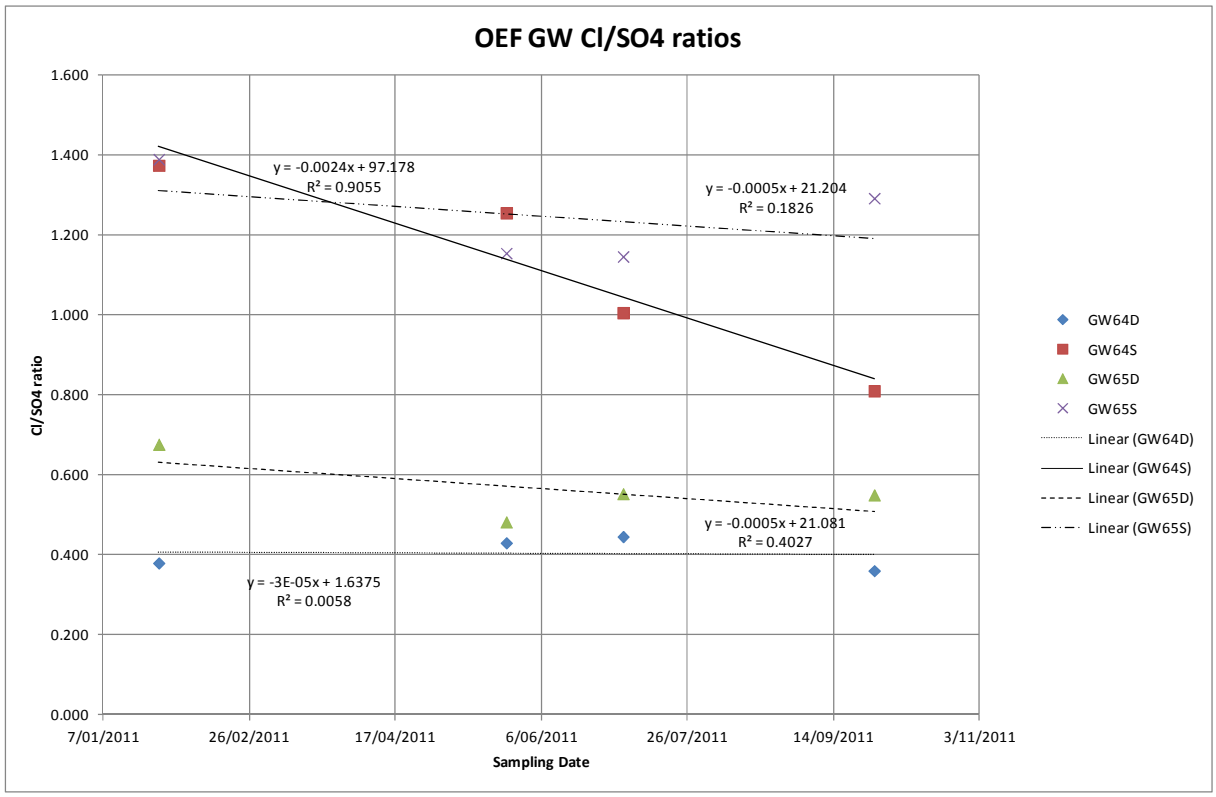


Figure 11 Chloride to sulfate ratios in groundwater in the vicinity of the OEF.

9.2.6 Review of MRM hydrocarbon spill response

The following comments are made following review of the report (MRM, 2012):

- MRM is complimented by the Independent Monitor on the level of technical detail in the data collected and reported upon, as well as the relatively reasonable nature of the conclusions drawn and recommendations made;
- a major observation by the Independent Monitor is that over 500 m^3 of hydrocarbon impacted soil has been taken to the TSF waste emplacement facility, hence bores GW4, GW6, GW14 and GW18 as a minimum should be monitored for TPH/ BTEX/ naphthalene (see Table 7 of MRM 2012 for CoPCs);
- Section 3.7.3.3 discusses natural attenuation (NA) mechanisms as demonstration of the occurrence and effectiveness of bio-degradation in reducing plume migration and mass. It is noted by the Independent Monitor that Figure 3-10 does not include solid phase manganese (MnIV) reduction as part of this process, yet dissolved Mn (or MnII) has been included in the analytical suite (Table 7) and is discussed adequately in the text of this section. MnIV reduction typically occurs in the redox range of <500 mV (between denitrification and FeIII reduction) hence is an important electron acceptor in bio-degradation. The data obtained (Table 7) suggests that this process is active at the site;
- it is noted by the Independent Monitor that alkalinity results (as discussed in the second-last paragraph of Section 3.7.3.3, p46) are also a very strong indicator of microbial respiration (production of $CO_{2(g)}$ which is converted to $HCO_{3(aq)}$ in the pH range 5-8), in addition to hydrocarbon mineralisation/ breakdown;

- the Independent Monitor agrees that the monitoring and remedial approaches adopted are appropriate for the scenario; and
- the Independent Monitor recommends that further effort be put into sourcing and installing more permanent flood and stock/ fauna resistant fencing, as this appears to have been the source of major hydrocarbon spills. In addition, more stock (cattle and donkeys in particular) were observed on the mine site during the 2012 inspection than previous years. The Independent Monitor is aware of fencing technology that is electrifiable and uses HDPE droppers and high tensile clips, which may be applicable to the mine site.

9.2.7 Review of MRM Audit of Hydrocarbon Infrastructure

The Independent Monitor has reviewed all hydrocarbon audit documentation, including MRMs plan for addressing all of the issues raised in the audits. In summary, the information that appears to be lacking is documentation that MRM have 'actioned' the items in the recommendations of the *Coltech Plannin Pty Ltd Engineering Report* for diesel plant at the Mine site (20 October 2011); all of which had a due date of no later than 3 March 2012. In addition, the following three issues are raised from the audit:

- the issue of there being no high level alarm on the aboveground diesel tanks (item 10 in MRM 2011). Applus recommended a high level alarm be installed and MRM have indicated they won't install a high level alarm, but rather will put in place a pressure transducer so that the tank level can be visually monitored. However, this will require manual monitoring at specified intervals (daily is nominated by MRM). While this solution apparently complies with the Standard (per Coltech's advice), it's reliance on manual monitoring means a level of risk is retained. Further, installing high level alarms is considered leading (if not standard) practice throughout the petroleum industry and shouldn't represent a big monetary investment when compared to the reduction in risk;
- the bund wall integrity was highlighted as a problem in the audit and Coltech confirmed that the wall needs repair. Item 7 in MRM (2011) states they are looking at costs and options and that if the current bunding is to continue to be used it will be repaired. The Coltech report goes on to advise that the bund wall needs repairing and then hydrostatic testing to ensure the "compound" is water tight. There is no mention of the bund base, which looks to be gravel. Leading practice is now to have a sealed bund floor and wall, hence the floor of the bund also needs to be sealed and tested if this is not already the case. These comments also stand for the bunding about the Avgas tank (Item 32 in MRM 2011); and
- Coltech's recommendations that the bund capacity needs to comply with the Standard should be addressed. Item 8 of MRM (2011) appears to state that MRM will address this, although this is not clear from the wording of the proposed action. These comments also stand for the bunding about the Avgas tank (Item 32 in MRM 2011).

9.2.8 Review of Golder Associates' TSF hydrogeochemical study report

Please refer to the Independent Monitors 2011 review report for a more detailed summary of this section. Key findings in the Golder report were:

- attenuation velocities were modelled for the average arrival times of dissolved Pb and Zn from the TSF at Surprise Creek. Predictions were the years 2092 and 2189 respectively, that is 97 and 194 years after initial tailings deposition;
- the tailings can be considered as non-acid forming (NAF), despite the high proportions of sulfide. This is understood to be due to the high proportions of dolomite and the presence of secondary carbonates;

- neutral and saline drainage is considered to be the primary form of seepage and impact associated with TSF Cell 1. The seepage expression at Surprise Creek is neutral to alkaline, with elevated concentrations of SO_4, Ca and Mg;
- the variability in concentrations of cadmium (Cd), Pb and Zn in monitoring bores is considered to be due to the variability in porosity and preferential pathways, thereby varying the attenuation and adsorption of these metals onto the solid phase; and
- the fractured bedrock underlying the alluvium is reducing the effectiveness of mitigation strategies through the occurrence of high porosity preferential pathways, hence seepage is still evident between the TSF and Surprise Creek and at Surprise Creek.

The recommendations from this study included:

- re-processing the tailings in TSF Cell 1, which will also allow the placement of a liner;
- construct a diversion of Surprise Creek further to the north-east of the current seepage recovery system to allow the existing creek channel to act as a larger interception trench, and then pump the collected seepage water back onto the TSF;
- construct a cut-off trench around the perimeter of the TSF to intercept seepage so that it can be pumped back to the mill; construct a physical barrier to retain saline seepage within the TSF footprint by filling the trench with bentonite or locally sourced clays, as well as a permeable reactive barrier using a range of materials to attenuate contaminants in the barrier;
- using a limestone or calcium-rich cover on the TSF to provide a source of alkalinity;
- incorporate the Golder installed monitoring bores into the current MRM groundwater monitoring program; and
- use kinetic tests to gain a greater understanding of the sorption and attenuation characteristics of the underlying alluvium and bedrock.

Limitations of the report are discussed in the Independent Monitors 2011 review report, however overall the Independent Monitor concurred with the recommendations of the study other than that the tailings will remain non-acid forming and that attenuation velocities for dissolved metals (Pb, Zn, Cd in particular) may have been under-estimated. Hence, there is the potential that these metals may impact Surprise Creek sooner than predicted.

Due to the significance of the seepage and the need to continually improve the understanding of the hydrogeology and hydrogeochemistry of the TSF, these studies need to be brought together by an organisation with competent and experienced hydrogeologists and geochemists. The Independent Monitor recommends that a separate and more robust hydrogeological and hydrogeochemical model and report should be developed and updated annually and that this report be provided as an appendix to MRM's annual WMP with the findings incorporated into the body of the report, including actions to address the recommendations made.

9.2.9 Review of URS TSF geophysical reports (EM Surveys)

Two recent geophysical surveys have been undertaken of the TSF, in October 2010 (URS, February 2011) and November 2011 (URS, April 2012). These reports generally conclude that areas of elevated conductivity (groundwater salinity) are present about the TSF, in particular along the eastern wall between boreholes GW18 and GW20A. To the north of the TSF (adjacent Cell 1 between boreholes GW42A and GW45B), increases in groundwater levels (and decreases in salinity) have been indicated. Further geophysical surveys have been recommended to track any changes over time.

The Independent Monitor recommends that future reports focus on comparison of new data with previous conditions. This will allow improvements (or reductions) in water quality (salinity), and changes in groundwater levels, to be discussed in the context of remedial works that are occurring about the TSF.

9.2.10 Review of URS Phase 3 development project EIS for groundwater

This document essentially provides a further detailed overview of site and surrounds geology, hydrology and hydrogeology, and uses this information to develop a conceptual model. Subsequently a domain for a regional flow model is set up and described. The flow model contains 11 layers, from surface alluvium to the basement Western Dolomite (which extends to a depth of about -600m AHD). The McArthur River Paleochannel (800m wide, average 8m thick) forms Model Layer 2.

The flow model was calibrated against hydraulic heads and pit inflow rates, which was the primary purpose for development of the model. The report states (Section 6.2, p43) "the model is best used for analysing inflow of groundwater into the open pit…focus on long-term time scales." This section goes on to state that "depth-dependent water-level data are needed, especially near the pit and…adjacent to the river diversion." Groundwater levels in the pit are expected to rebound within 1.5 years of the cessation of dewatering, however the water levels in the pit are not expected to stabilise for some 300 to 400 years.

It is noted that this report was reviewed by Dr Frans Kalf of Kalf and Associates (Appendix E). This review points out that whilst limited reliable hydrograph data was available for calibration against model predictions, especially from deeper aquifers and fault zones, inflows recorded from the existing open pit and underground workings were available. The review concludes "the model as it currently stands is considered the best that can be achieved given the data set available".

9.2.11 General groundwater management conclusions and recommendations

The general conclusions and recommendations for groundwater monitoring and management include:

- borefields:
  - monitoring water levels in borefield abstraction and surrounding observation bores prior to, during, and following cessation of pumping cycles (installation of pressure transducer data-loggers in at least some wells would be advantageous);
  - constructing hydrographs of pressure levels in all borefield abstraction bores and nearby observation bores, including rainfall and abstraction volumes and rates; and
  - assessing data such as recovery rates following cessation of pumping and drawdown rates during constant discharge;
- OEF:
  - hydrographs be constructed for monitoring bores GW64S, GW64D, GW65S and GW65D to allow assessment of changes in groundwater pressure over time; and
  - installation of nested monitoring bores (as with GW64 and GW65) be considered in the northern and eastern OEF where seepage is currently occurring;
- TSF:
  - as over 500 m^3 of hydrocarbon impacted soil has been taken to the TSF waste emplacement facility, bores GW4, GW6, GW14 and GW18 as a minimum should be monitored for TPH/ BTEX/ naphthalene (if not already done so); and

  - combining hydrogeological and hydrogeochemical data and development of a conceptual model for the TSF based on this data (updated annually);

- hydrocarbon infrastructure monitoring/ management:
  - 'actioning' of the items in MRMs report of 20 October 2011;
  - installation of a high level alarm on aboveground diesel tanks;
  - sealing and integrity testing of bund walls and floors for all hydrocarbon storage facilities; and
  - improvements to fencing technology to keep stock and other fauna off the mine site;
- quality assurance and control (QA/QC) reporting presentation has improved with the inclusion of TDS/ EC and field/ lab pH plots for each sampling location. However, aspects of the QA/QC reporting should include discussion on comparison of field to laboratory results, in particular:
  - TDS/EC ratio (acceptable range of 0.55-0.80);
  - field pH to laboratory pH relative percent differences (RPDs), with an acceptable RPD of 10%;
  - RPD between field collected blind (intra-laboratory) duplicate samples and split (inter-laboratory) duplicate samples, including presentation and discussion of results and elevations in RPDs in particular; and
  - discussion of findings of the laboratory's quality control reporting;
- analytical suite:
  - analysis for metals be limited to dissolved species including dissolved Al, Fe and Mn; and
  - a full cation and anion ionic balance be undertaken on all samples (pH, TDS, Na, Ca, Mg, K, Cl, SO_4, HCO_3, NH_3, NO_3, NO_2, PO_4 and F);
- general data interpretation and reporting:
  - groundwater contours in each separate formation, but particularly the bedrock and the alluvium, need to be presented at least bi-annually; at the end of wet and end of dry seasons. These can also be used as a check against the predicted drawdowns in the updated URS groundwater model (URS January 2012). Separate groundwater contour figures using all available bores should be provided for the TSF, the regional monitoring network and Bing Bong, as well as the OEF once further bores are installed. These will enable greater interpretation of groundwater flow direction(s) and hydraulic gradients and, in turn, provide visual representation of the significant factors in groundwater impacts from the MRM operations. This is a recurring recommendation by the Independent Monitor and is yet to be adequately addressed.

9.3 Review of Dust Monitoring

9.3.1 Dust monitoring program overview

According to the 2011/2012 Mining Management Plan (MMP) the dust monitoring program comprises 21 depositional gauges located at the mine site and six located at the Bing Bong Port loading facility (see Figure 12 and Figure 13). The gauges remain in place for a period of 30 ± 2 days, as per AS/NZS 3580.10.1:2003 (Standards Australia, 2003), after which they are analysed for total insoluble matter (TIM), lead and zinc. As noted by MRM the primary factor that determines the potential location of dust deposition is the direction and speed of seasonal winds. The primary areas of concern for contaminated dust generation continue to be the PACRIM ore crushing area at the mine site, and the Bing Bong concentrate storage shed at Bing Bong Port.

The Independent Monitor observed that the number of mine-site monitoring locations in the 2011/2012 MMP (21 locations) does not match the number of monitoring locations shown in the November 2011, MRM Environmental Monitoring Manual (15 location), with the following monitoring locations being absent: D21, D20, D17, D3, D5 and D19. Further, within the MRM Environmental Monitoring Manual, a depositional dust gauge is referred to as “active dust monitor”, although the gauge uses a passive method. Consistency between these documents should be maintained in future. It is also noted that the Environmental Monitoring Manual often refers to the AS3580.10.1-1991, which has since been superseded by AS/NZS 3580.10.1:2003.

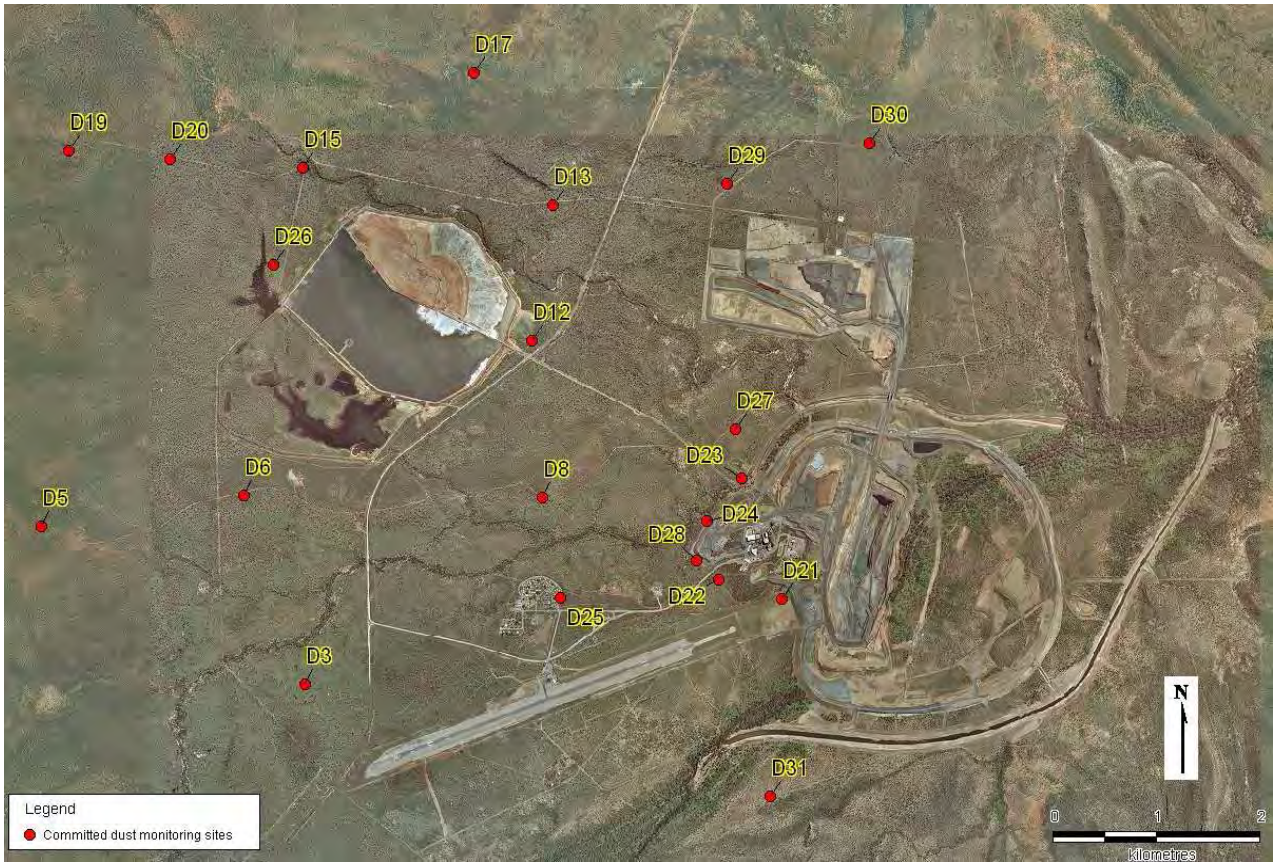


Figure 12 Dust Monitoring Locations at MRM (Figure Sourced from the 2011/2012 MMP)

Figure 13 Location of depositional dust monitoring Bing Bong Port. (Figure sourced from 2012-2011 MMP)

9.3.2 Update since the previous audit

The issues detailed below were identified by the Independent Monitor as either not resolved or only partially resolved during the previous audit of the 2010 Operational Period, conducted in 2011. An update into these specific issues is provided in Table 8 below.

TABLE 8 UPDATE ON IDENTIFIED ISSUES IN RELATION TO DUST MONITORING

Observations from previous audit	Comment this Audit
Dust mitigation needs to be increased at PACRIM area.	The Independent Monitor observed upgrades for dust mitigation at the PACRIM area during the May 2012 inspection. There was significantly less concentrate dust observed overlying the area. It is also understood that MRM plan on implementing a concentrate dust recovery program.
Concentrate bearing dust was observed on banks of Barney Creek diversion rehabilitation area.	No dust was observed overlying the area. Improvements in dust mitigation at the PACRIM area was observed during 2012 site visit.

Observations from previous audit	Comment this Audit
Purchase a street sweeper for the Mill, Barney Creek Bridge and PACRIM yard roads to aid in dust suppression.	Incomplete but the Independent Monitor has seen evidence that this will be implemented by MRM The Independent Monitor understands that A street sweeper does not appear to have been implemented as discussed in previous audits.
Place a vegetation barrier between ROM pad and main road.	No, however this is planned. MRM have indicated that this will be undertaken. However, no date has been given.
Roller doors remain open at all times and this increases the chances of rogue dust. MRM should investigate the possibility of an extraction system for concentrate shed.	This has not been completed yet, however the Independent Monitor has viewed specific plans for the implementation of the system. The Independent Monitor has been provided with design specifications of the negative pressure system to be implemented at the concentrate shed.
Sampling gauges need to be left for 30±2 days as per AS/NZS 3580.10.1:2003.	Incomplete, however the Independent Monitor understands that on occasions this may not be achievable. The Independent Monitor understands that inclement weather/unsafe conditions may sometimes prevent compliance. The Independent Monitor has reviewed the COCs and has noted that an explanation was recorded for son missing timeframes, whilst others are not explained.
No discussion is provided in terms of spatial or temporal trends with regard to Pb, Zn and TIM results.	The Independent Monitor has noted a significant improvement in the reporting of monitoring results.
TIM, lead and zinc levels have increased over time, especially in Bing Bong, TSF and PACRIM areas.	Improvements have been noted, however planned improvements should see further decreases in future monitoring. Overall levels (i.e. TIM) have decreased at problem areas (e.g. PACRIM and Bing Bong) however remain elevated at the PACRIM
Laboratory QA/QC documentation was only partially provided.	No laboratory QA/QC documentation was provided this year (i.e. condition of samples, timeframes, etc).

9.3.3 Observations from site inspection

Considerable improvements were observed by the Independent Monitor team during the May 2012 site inspection with respect to dust generation at the PACRIM ore crushing area. In general, less concentrate dust was observed overlying the surrounding area, or visibly emanating from the plant than in previous years, which is a positive improvement. This result has been achieved through increasing dust suppression sprays over the PACRIM conveyor system (Plate 5).

The Independent Monitor observed that the Bing Bong Concentrate Storage shed roller doors still remained open in May 2012, which has been an ongoing concern identified by the Independent Monitor. This audit period, MRM provided documentation to the Independent Monitor as evidence that improvements to the storage shed have been approved.

Plate 5 PACRIM crushing plant located on the ROM Pad at the mine site. Note the area is kept moist with sprays on the conveyor belts to limit dust generations.

The Independent Monitor inspected a recently-installed real-time air monitoring. Housed in a small shed at the north-western perimeter of TSF Cell 1 (Plate 6), this monitoring system has been set up to provide real-time alerts to the Environment team when dust levels exceed criteria. MRM have advised that they are preparing to install a second monitoring shed downwind of the PACRIM crushing area, which has been the primary source of contaminated dust generation.

Plate 6 New real-time air monitoring shed positioned at the upwind perimeter of TSF Cell 1.

MRM personnel identified further improvements to the mitigation and monitoring of fugitive dust across the mine site and Bing Bong Port, which are outlined below in Section 9.3.6.

9.3.4 Review of dust monitoring program reporting

The results of the dust monitoring program for the 2011 Operational Period are reported in section 5.2.3 of the Sustainable Development Mining Management Plan (MMP) 2011/2012.

The Independent Monitor has noticed significant improvements in the reporting and presentation of dust monitoring results, namely by the inclusion of the following:

- description of wind patterns at the mine site and Bing-Bong;
- description, location and rationale for each monitoring point;
- the recommended guideline threshold of 4g/m2/month for total insoluble mater (TIM);
- comprehensive charts depicting current and historical results for all locations;
- appropriate discussion of observed trends; and
- planned upgrades for mitigation and monitoring.

Whilst MRM is correct in that the 4g/m^2/month trigger for TIM depositional dust is not directly applicable to mining operations as it correspond to a “nuisance threshold”, it is a value widely used by other mining operations and furthermore, provides a trigger for excessive dust levels and a positive target.

The Independent Monitor agrees with the inclusion of this extra information and commends MRM for the considerable improvement of the dust management and monitoring section of the MMP. However, minor issues have been identified which should be addressed for further improvement of MRM’s dust monitoring and management reporting. These issues are detailed below.

The Independent Monitor has repeatedly requested that MRM provided QA/QC laboratory documentation related to dust analysis, however, this was again not provided this year. It is unknown whether the laboratory used for undertaking the analysis provides this information to MRM. It is also noted that these are not NATA endorsed reports nor have they been authorised (i.e. they are not signed). MRM should query the laboratory into their NATA accreditation to undertake the analyses and request all reports be signed and authorised.

It is noted that some of the charts contained in the MMP provide lead and zinc loads values (i.e. in mg/m^2/month), which are incorrectly referred to as “lead and zinc concentrations” while other charts provide (appropriately named) concentrations (i.e. in mg/kg). MRM are reminded that these units are not comparable as the unit mg/kg refers to the portion of Pb or Zn (i.e. concentration) in a sample, while the unit mg/m2/month refers to the total amount per area/unit time (i.e. load).

The Independent Monitor provides further guidance for the potential interpretation of dust results for “loads” and “concentrations” in Table 9 below.

TABLE 9 TIM AND LEAD/ZINC CONCENTRATIONS RESULTS POTENTIAL INTERPRETATION

	TIM (in mg/m^2/month	Lead and zinc concentrations (in mg/kg)	Potential interpretation
TIM and Pb/Zn results	High	High	Significant fugitive dust generation with a likely high mineral concentrate signature. High potential for contamination.
	High	Low	Significant dust being generated however without Pb/Zn concentrate signature. Lower potential for pollution but depending on levels could pose sedimentation issues.
	Low	High	Low amount of dust, however with potential concentrate signature. Investigate.
	Low	Low	Low dust and low Pb/Zn. No concern.

Table 9 highlights the importance of conducting both analyses as TIM results provide an overview of the total dust loads while Pb/Zn concentrations relate to the proportion of mineral concentrate contained in the dust generated.

It is also acknowledged that the McArthur River Mine site is located in a mineralised area and non-mine generated ("natural") dust could also have elevated Pb and Zn concentrations. As such, specific factors also need to be considered for each monitoring location (e.g. where is the monitoring point located, how high are the concentrations, etc.). However, the effect is likely to be small as the lead outcrop footprint was reportedly small.

The Independent Monitor notes that, in general, MRM complies with the required timeframe of 30 ± 2 days required by Australian Standard AS3580.10.1:2003 for depositional dust monitoring and analysis. Where breaches did occur in the monitoring period, some of the chain of custody (COC) forms do provide explanations as to why the timeframe was breached (e.g. inaccessible location, etc); however not all of the COCs contain this information. It is recommended that this information be consistently recorded without exception.

9.3.5 Review of dust monitoring data

Mine-site

As in previous years, the highest TIM levels and Pb/Zn concentrations correspond to locations near the PACRIM / ROM pad area. However, the Independent Monitor agrees with MRM's assessment that mitigation measures appear to be having some positive effect in reducing the TIM levels and lead/zinc concentrations particularly at some monitoring locations nearby the PACRIM / ROM pad (i.e. D22 and D28) since 2009. It is also understood that further measures are planned at the area (see Section 9.3.6, for planned improvements) and as a result, the Independent Monitor expects to observe further decreases in subsequent audits.

Figure 14 has been provided to show the TIM levels in locations near the PACRIM / ROM pad. Note the decrease in TIM levels since 2009.

In general, all other locations appear to show TIM levels below the recommended guideline threshold of 4g/m^2/month.

Bing Bong Port Facility
A notable decrease in TIM levels since 2009 has been observed for locations BBD01, BBD02, BBD03 and BBD04 (see Figure 13). The Independent Monitor is pleased to see that dust mitigation measures employed by MRM appear to have been effective for controlling dust emissions at these areas. It is nevertheless suggested that vigilance be kept in location BBD02, which showed a total zinc result of almost 500mg/m^2/month for July 2011.

It is also noted that in general whilst TIM levels seem to have decreased, Pb/Zn concentrations do not. This highlights that although dust has been mitigated effectively, the proportion of mineral concentrate in dust has remained similar and therefore further mitigation (such as those already planned) are needed at the area.

With regard to location BBD05, the Independent Monitor agrees with MRM interpretation that elevated dust are most likely associated with traffic movement at the area. It is highly recommended that the frequency of the water truck be increased at this area particularly in the dry season.

It is also noticed that TIM and lead results for Bing-Bong monitoring location BBD06 in Table 5-3 of the MMP are the same. Judging from results presented in later charts, this is deemed a typographical error.

It is understood that MRM changed the analysis of total solids (TS) for TIM and that these parameters are not comparable; thus, only two years of data are presented in trend charts. The Independent Monitor however reiterates that the analysis of total Pb and Zn mass and concentrations has not changed thus these results could be presented in future MMPs particularly for problem areas (i.e. PACRIM and Bing-Bong). Figure 15 shows the TIM levels in locations at Bing Bong. Note the decrease in TIM levels since 2009.

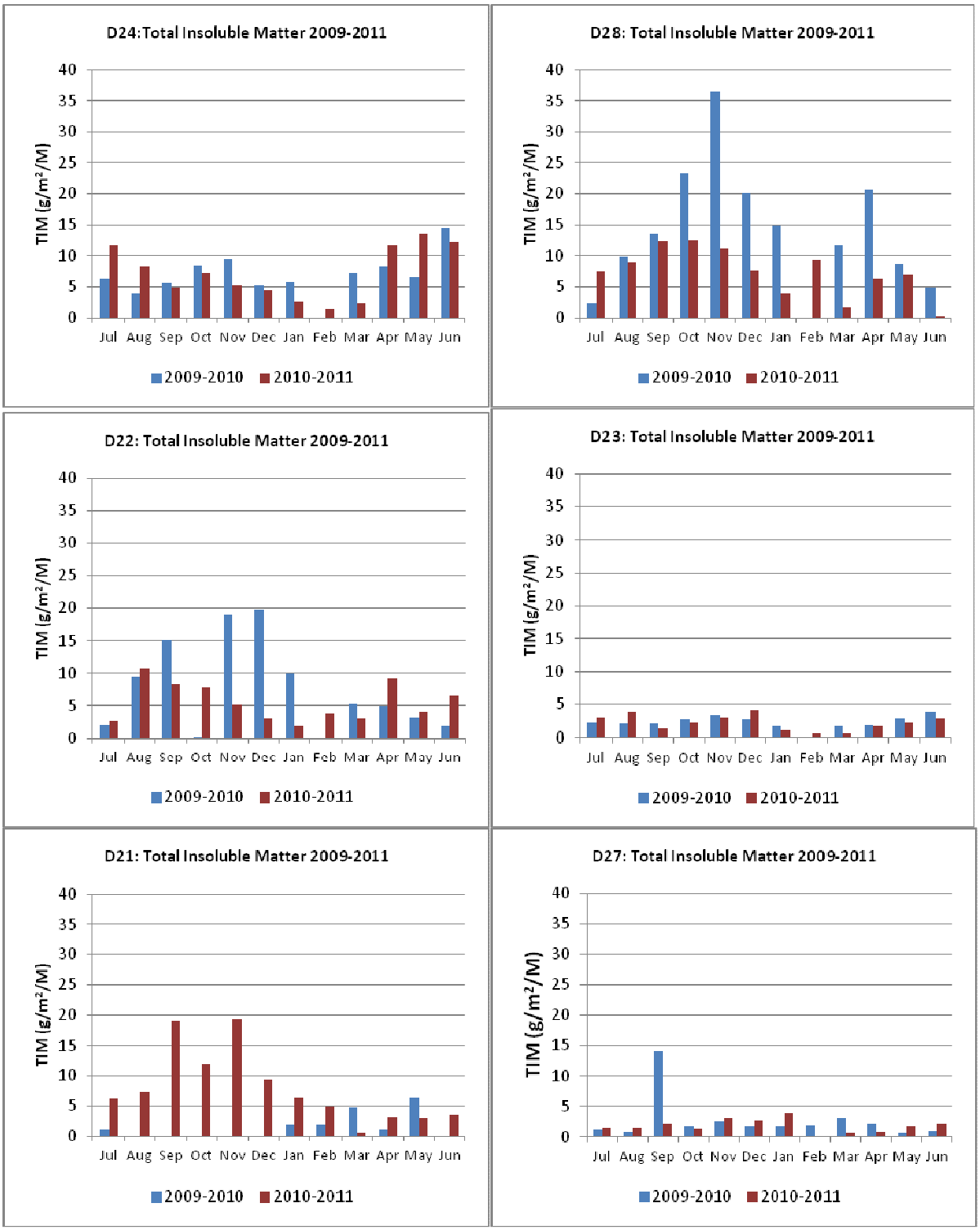


Figure 14 TIM levels in locations at locations within 1km from the PACRIM / ROM pad. (Figure source: 2011/2012 MMP)

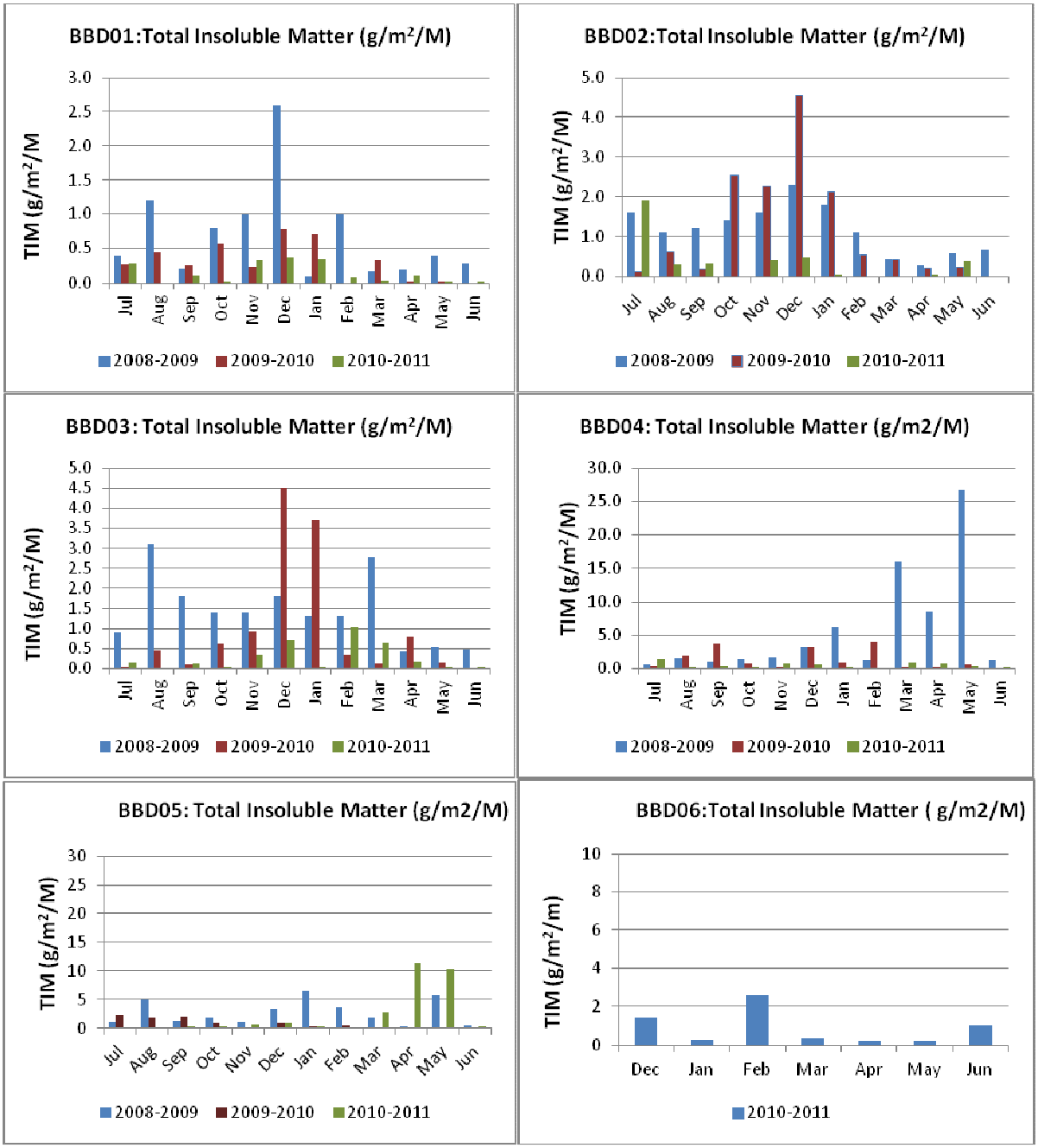


Figure 15 TIM levels in Bing Bong locations. (Figure source: 2011/2012 MMP)

9.3.6 Improvements and planned upgrades

The Independent Monitor understands the following upgrades are being planned for dust monitoring and mitigation throughout 2012:

- implementation of a Tapered Element Oscillating Microbalance (TEOM) analyser for continuous air quality monitoring;
- purchase of a MiniVol® air sampler unit for monitoring specific areas;
- replacement of the mill concentrate shed roof and side sheeting;
- vegetation barrier between the ROM Pad and main road;
- statistical software to improve current interpretation and reporting; and
- review design of dust monitoring locations.

9.3.7 Conclusions and recommendations

MRM have shown improvements in terms of implementation of further dust mitigation measures, and the reporting of results from their monitoring program. It is pleasing to see that the Independent Monitor's recommendations put forward over the years have resulted in a general decrease in fugitive dust emissions and increase environmental performance in this respect. Moreover, the planned technological upgrades for monitoring and mitigation of dust indicate MRM's commitment to further improvement.

Key points for further improvement include:

- continual increases in dust mitigation measures at Bing Bong and PACRIM/ROM pad;
- ensure that QA/QC documentation is always obtained from laboratory conducting dust analyses; and
- address minor reporting issues.

9.3.8 Overview of the previous five years of dust monitoring

Since the Independent Monitor's initial audit in 2008, dust management and mitigation has remained as priority issue of concern. Previous concerns have primarily been associated with insufficient dust mitigation measures and inappropriate reporting of monitoring results. Such deficiencies have resulted in fugitive contaminated dust emissions in areas of the mine site and Bing Bong port, which have the potential to cause environmental contamination and affect ecosystem health.

Dust Monitoring and Management has improved significantly since the first Independent Monitor audit undertaken in 2008. Significant improvements have included the following:

- Cell 1 of the TSF has been completely capped with clay to mitigate the generating of tailings dust;
- areas of the roof of the concentrate storage shed at Bing Bong has been repaired to prevent escape of concentrate dust;
- dust mitigation at the PACRIM ore crusher area has improved in the past two years, with the implementation of additional sprays and other updates to the plant; and
- reporting and data presentation of dust monitoring within the MMP has improved each year since the initial Independent Monitor audit.

The Independent Monitor's audit for the 2009 Operational Period revealed some improvements in dust mitigation at the PACRIM plant, particularly with the implementation of double-lipped rubber liners on the conveyor belt system. The Independent Monitor team again observed concentrate-laden dust on the banks of a tributary of Barney Creek (although less widespread) and indentified the potential for dust from the concentrate shed at Bing Bong. It was also identified that no dust monitoring was being undertaken near the overburden emplacement facility (OEF), the southern side of the McArthur River channel, nor in the swing basin. Issues highlighted in terms of reporting of dust monitoring data were again deficient in reporting of dust trends and results, and inconsistency in the parameters being analysed by MRM.

Some improvements with regard to dust mitigation and management were noticed in the 2011 Independent Monitor audit (for the 2010 Operational Period). Additional controls at the crusher were noted and no dust was observed overlying Barney Creek as opposed to the previous years. Nevertheless, still considerable dust was emanating from the PACRIM. Again, it was highlighted the issue of the doors kept open at the Bing Bong concentrate shed, however MRM this time advised of plans to implement an engineering solution to the problem. It was also highlighted that MRM only monitored depositional dust, which is deemed insufficient (e.g. not providing PM10 data). Two new monitoring locations near the OEF, one south of the McArthur River channel and one in the swing basin were implemented following the Independent Monitor recommendations. Generally, dust and lead/zinc levels were found to be similar but no decreasing trend was observed.

In the current 2012 audit (for the 2011 Operational Period), it is pleasing to see that the great majority of the issues identified over the years have been resolved, and that the Independent Monitor recommendations have been implemented through major improvements done by MRM to their dust management, mitigation and monitoring program. MRM is thus commended for its commitment to continuous improvement; however, as outlined in Section 9.3.7 above, there are still improvements to be made.

9.4 Review of Soil Monitoring

9.4.1 Soil monitoring program overview

According to the MMP 2011-2012 (MRM, 2011) a soil monitoring program is conducted annually at the mine site and the Bing Bong Port facility. Surface soil samples (0-0.03 mBGL) are collected next to each dust monitoring gauge immediately prior to the wet season and then submitted for analyses for heavy metals/metalloids (arsenic, cadmium, copper, iron, manganese, lead and zinc); cations (calcium, potassium, magnesium and sodium); pH, electrical conductivity (EC) and particle size analysis (PSA). Although the soil monitoring program is considered generally appropriate, it is believed that there is still significant room for improvement.

The soil monitoring sampling locations are presented in Figure 16 (mine site) and Figure 17 (Bing Bong Port)

It is noted that the current MMP (2011-2012) shows 21 monitoring locations, whereas raw data received from MRM suggests 26 sampling locations. This would represent an increase from the 23 locations in 2011 and 21 locations in 2012 however; given the large area of the mining lease, the number of current soil monitoring locations is still considered insufficient. Due to the relatively low number of soil sampling locations over the large area of the mining lease, it is difficult to make an accurate assessment of the net impact of the mine operation on soil in the area, or to determine the extent to which areas have been contaminated.

Whilst it is understood that MRM have no desire to increase the spatial density of its soil monitoring program, it is recommended that one survey with a much greater spatial density be conducted at least every five years to accurately gauge the extension of the areas currently impacted by the mine's activities. Another alternative is to conduct sampling and analysis with greater density in areas where concentrations exceed the EILs, or where temporal monitoring trends are increasing.

It is understood that it is MRM's commitment to return the land to the same (or better) state following the cease of mining operations. It is however not known how this will be achieved without knowing the full extent of mining impacts on soil quality.

9.4.2 Review of soil monitoring reporting

The results and reporting for the latest soil monitoring program are found in the 2011/2012 MMP. As mentioned earlier, it is noted that the 2011 results have been reported in the MMP without any consistent discussion of impacts. Notwithstanding this, it is noted that MRM have made significant improvements in the latest MMP, namely:

- provision of background information as to the occurrence of soil types within the lease and their characteristics;
- provision of description for each sampling location and distance to a potential contaminating source; and
- provision of concentration charts for the current and past 2 monitoring periods for all locations.

It is also noted that data is now presented in groups according to their distance to a particular potential source of contamination. This approach represents a significant improvement in the presentation of data when compared to previous years and will potentially assist in the delineation of soil impacts.

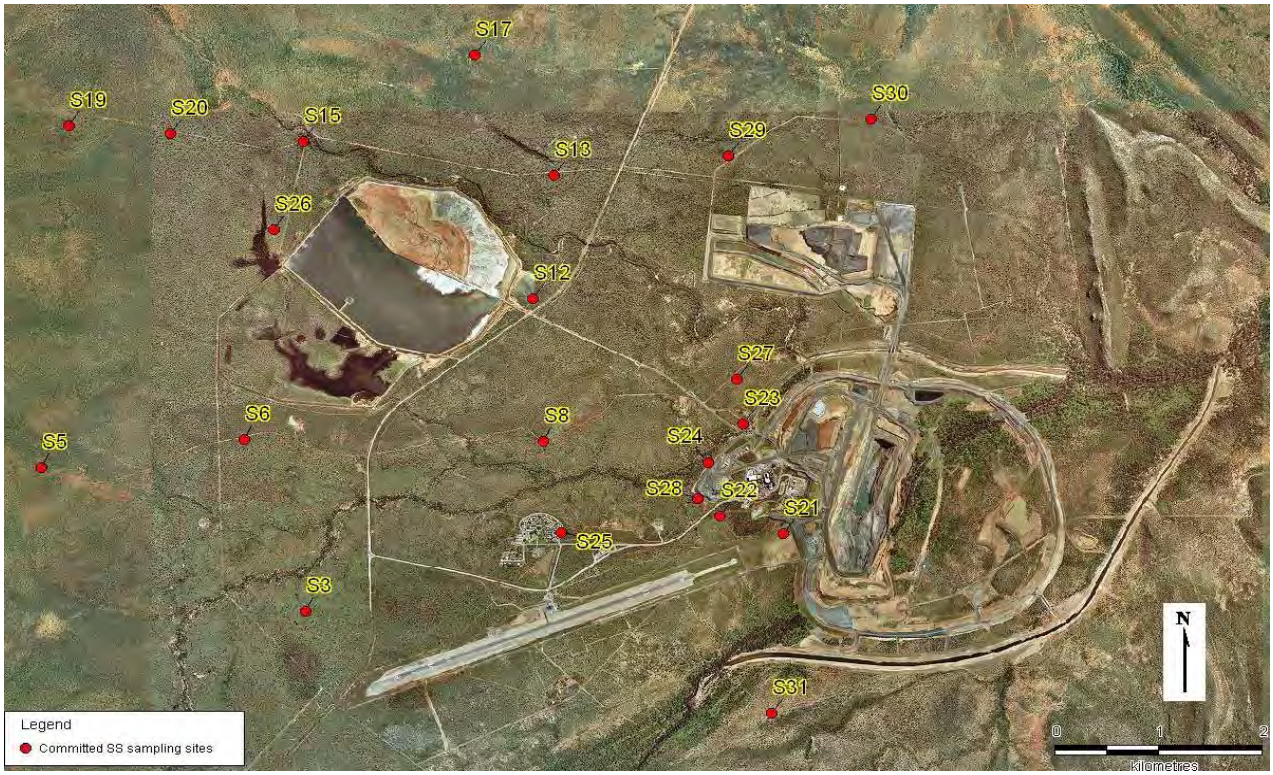


Figure 16 Soil monitoring locations at the Mine site (Figure sourced from 2011/2012 MMP)

Figure 17 Soil monitoring locations at Bing Bong Port (Figure sourced from 2011/2012 MMP)

The Independent Monitor also notes that MRM have provided complete laboratory transcripts with quality assurance, quality control (QA/QC) documentation and accompanying chain of custody forms (see however error in the analytical chain in Section 9.4.3 – Review of soil monitoring data). No breaches to QA/QC in the sampling or analysis process were sighted in these forms. It is noted however that no field QA/QC—that is, duplicates, split samples—section is provided in the MMP so it is assumed that these were not collected.

It is noted that MRM now use the more conservative NEPM Environmental (or Ecological) Investigation Levels (EILs) instead of the NEPM Human Health Investigation Levels (HIL; NEPC, 1999) as trigger values for contaminants in soil. The Independent Monitor considers this an advancement in the assessment of heavy metal impacts in soil, however MRM is reminded of their commitment in the Preliminary Mine Closure Plan (March 2008) to derive site-specific investigation levels or background metal levels. However we also note that this commitment is not included in the *Mine Closure Plan – MRM Phase 3 Development Project January 2012.*

The Independent Monitor understands that MRM collects soil samples close to dust monitoring locations to compare both results, yet the assessment of soil results with depositional dust metal concentrations is not considered sufficient. Similarly, no correlation assessment of soil metal results and nearby creek sediment has been undertaken. These assessments would be very useful for a better understanding of fate and transport processes.

Although there is discussion of all parameters analysed, it appears that there is not a thorough understanding of the implications of these parameters. From a soil science perspective, results are only relevant when these are interpreted correctly, and serve to both inform and drive management actions. The following areas are deemed to require further discussion:

- salinity and pH trends in areas near the TSF and OEF;
- sodicity and erosion potential of soils; and
- heavy metals concentrations in fine fraction of the soil.

Further, the laboratory analytical program undertaken is comprehensive, although it is noted that MRM request for total concentrations of soil cations. Total soil cations do not allow the calculation of the sodium absorption ratio (SAR) which is calculated using exchangeable cations. The SAR is a very useful indicator of dispersivity and erosion potential of the soil and should be incorporated in MRM's reporting.

In the opinion of the Independent Monitor, MRM arbitrarily state that the "high level of natural mineralisation is a major contributor to the metal component of the soil". This is not supported by any background level data derived by, for example, isotope analysis or comparing with soils further from the mine but with similar physicochemical characteristics (e.g. CEC, pH, particle size, etc). Nor it is supported by the fact that the weathered mineral outcrop had a reportedly small footprint.

9.4.3 Review of soil monitoring data

As mentioned above, the results for MRM's soil sampling program undertaken during the 2011 Operational Period are not adequately discussed in the 2011/2012 MMP. The 2011/2012 MMP states "laboratory analysis for soils samples collected in 2011 are expected to be available in the near future…" No other explanation has been provided for this omission. It is also noted that MRM's sample submission sheet reads "date sampled 29/8/11 to 19/9/11" and date dispatched "1/12/11" suggesting the samples remained on-site idle for

over ten weeks. Moreover, no results have been sighted for soil samples collected at Bing Bong.

There also appears to be an error in the analysis undertaken by the laboratory. Inspection of the COC submitted to the laboratory revealed that MRM requested heavy metals analysis in the <2mm fraction, yet the laboratory undertook heavy metal analysis of the <2µm fraction. It is thought that the confusion arose from requesting <2mm sieving which is not necessary as this is standard laboratory practice for "total" fraction heavy metal analysis.

In general, guideline triggers (i.e. EILs) are to be compared to the "total fractions", however since finer particle sizes have greater metal adsorbing capacity than coarser particles (i.e. concentrations are expected to be higher in the fine fractions), comparing the <2µm fraction results to the prescribed guidelines is seen as a conservative approach. The Independent Monitor has thus reviewed the results from the 2011 and details locations exceeding the EILs in Table 10 below.

TABLE 10 MONITORING LOCATIONS EXCEEDING THE EILS DURING THE 2011 SOIL SAMPLING

Monitoring Location	Description of location	Distance from potential source	As	Cd	Cu	Pb	Zn
S05	Drainage line flowing into upper Barney Creek	7km (PACRIM)	82	–	–	–	1340
S08	Approx halfway between PACRIM and TSF adjacent to little Barney Creek	2km TSF and PACRIM	–	–	–	–	381
S15	Adjacent to TSF clay borrow pit	1.8km TSF	–	–	–	–	406
S22	Adjacent to sealed road entrance to mine administration	0.5km PACRIM ROM Pad	47	5	–	1030	2080
S23	Barney Creek crossing	0.5km PACRIM ROM Pad	–	–	–	–	434
S24	Adjacent to ROM Pad	<0.5km PACRIM ROM Pad	44	4	–	1130	1820
S28	Between ROM Pad and Barney Creek	0.5km PACRIM / ROM Pad	163	16	185	4130	7260
Environmental Investigation Levels			20	3	100	600	200

Note all results are for the <2µm fraction and in mg/kg.

Similar to previous years, the highest concentrations are found in PACRIM / ROM pad locations S22, S24 and particularly S28. These coincide with the highest depositional dust and Pb/Zn concentrations recorded by the dust monitoring program.

Monitoring locations S15 and S8 are not excessively elevated and thus are not deemed to pose a major concern, vigilance must however be observed for these locations. MRM state that elevated concentrations at sampling location S05 are not due to transport by surface water as this location is upstream of the TSF. MRM is encouraged to conduct further assessment of this area by collecting samples upstream and downstream of this location (within the same drainage line) to support such statement.

Although elevated levels were noted at the locations detailed in Table 10, a comparison of lead, zinc and arsenic concentrations between samples collected in 2010 and 2011 revealed that concentrations have generally decreased (see Figure 18 to Figure 20 below). Only monitoring location S28 showed an increase, however this can also be due to using the >2µm fraction analysed in the latest monitoring program (2011) data and hence total concentrations in location S28 are generally lower.

These decreases in metal concentrations are considered positive, however since MRM have not undertaken any remediation this also poses the question as to fate of contaminated soil (i.e. is this being transported to nearby creeks or other areas?). The potential transport of contaminated soil offsite is not considered acceptable, although evidence in the delta indicates transportation of lead dust from the mine site was occurring in 2007 (as reported in the Independent Monitor's audit report for the 2007 Operational Period).

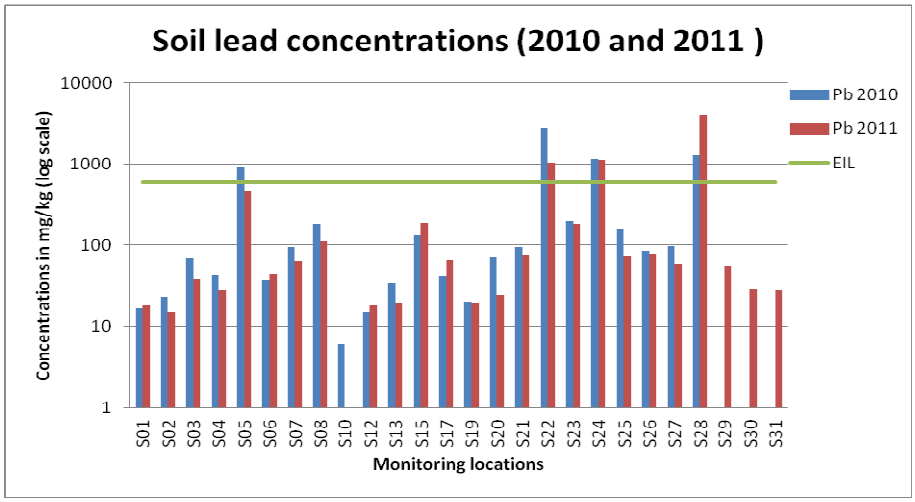


Figure 18 Comparison of soil lead concentrations between 2010 and 2011

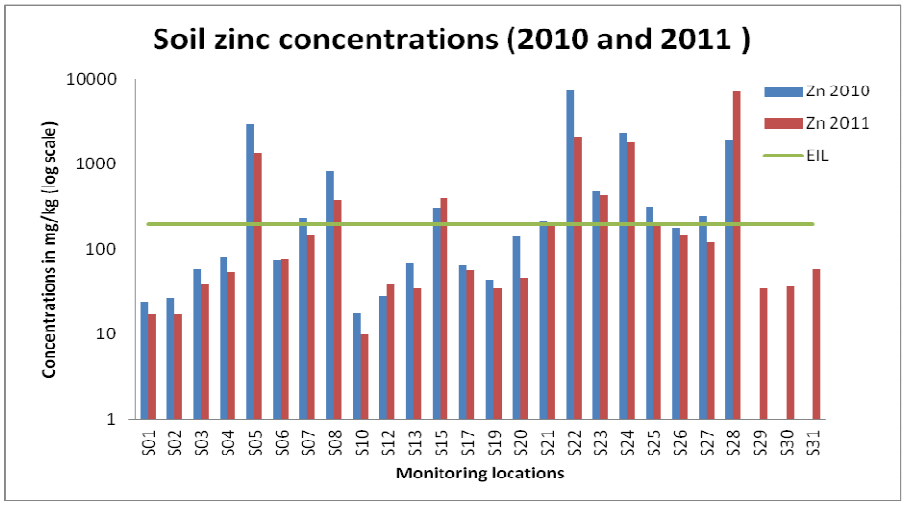


Figure 19 Comparison of soil zinc concentrations between 2010 and 2011.

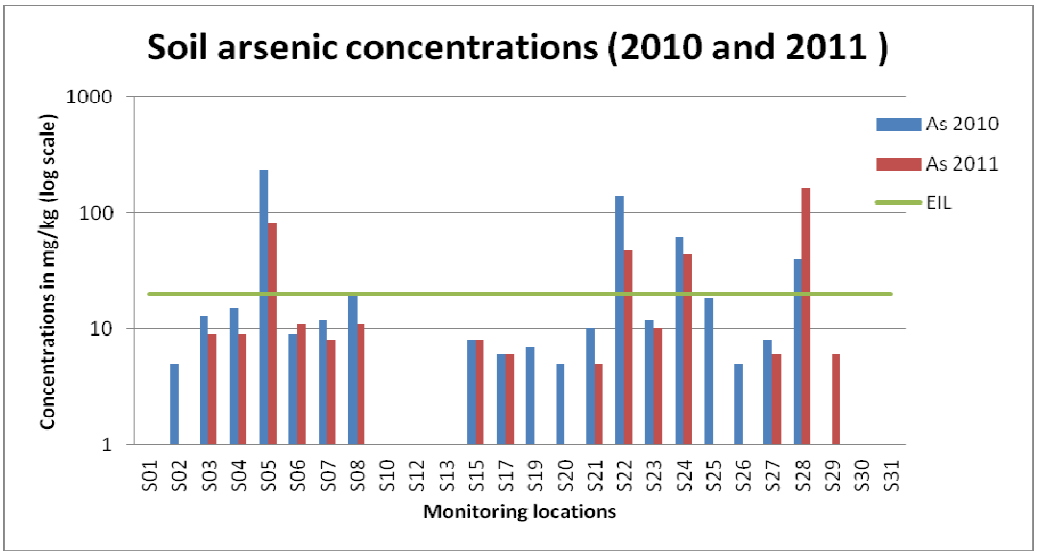


Figure 20 Comparison of soil arsenic concentrations between 2010 and 2011

9.4.4 Conclusions and recommendations

Evidence of soil contamination has been noted due to dust deposition and potentially surface water transport, particularly in locations near the PACRIM / Rom Pad. This issue has been highlighted in all Independent Monitor audits conducted to date. Due to the lack of studies, it is not known whether these elevated concentrations are affecting local biota. Furthermore, the total extent of contamination is not known to the accuracy required due to the deficient density in sampling. It is noted that one of MRM's objectives for the soil monitoring program is the "accurate assessment of the soil physico-chemical properties". At this stage, MRM are not achieving this objective in terms of spatial coverage or in the interpretation of soil monitoring data.

Consideration should be given to undertaking soil sampling in areas outside the mining lease, ideally in both upwind and downwind locations, to assess whether any mining impacts are occurring outside the mine site due to wind or water transport and deposition.

On a positive side, it is seen that the level of the reporting of soil monitoring data has increased with the inclusion of descriptions of monitoring locations, and general interpretations of elevated concentrations. However, the correlation of soil data with sediment data has again been absent in the MMP.

Data also suggests that metal concentrations at most locations have been decreasing. Whilst this is deemed positive, it also suggests a potential of mobilisation of contaminated soil outside mine lease areas, which is not deemed acceptable.

The reasons for the delay of the inclusion of 2011 monitoring data in the most current MMP are not known. Nevertheless the error identified in the analytical procedure is concerning and highlights a deficiency in MRM QA procedures. Caution and vigilance is advised when requesting laboratory analysis and results must be thoroughly checked by MRM staff as soon as received to flag and amend any potential errors. The Independent Monitor has encountered errors in the analytical procedures in more than one occasion. This may render the entire monitoring program useless or even worse, drive incorrect management actions.

With regard to MRM's current soil analytical suite, the Independent Monitor provides the following guidance as detailed in Table 11.

TABLE 11 PROPOSED ANALYTICAL PARAMETERS FOR MRM SOIL MONITORING

Parameter	Rationale
pH	Measure of soil acidity or alkalinity. Can indicate impact from acidic leachate
EC	Proxy for soil salinity. Can indicate impact of saline leachate, rising watertable, etc.
Exchangeable cations	Allows the calculation of the SAR as a measure of dispersivity of the soil and thus erosion potential
Total metals	Provides indication of soil metal enrichment and also allows comparison to trigger levels
<63µm metals	Given that total metal concentrations can be confounded by particle size (i.e. metals are adsorbed more to finer fractions), the analysis of the <63 µm fraction serves to normalise concentrations and permits the determination of temporal and spatial trends.
Total S	Consider adding total S to the analytical parameters for locations near the TSF and OEF to detect potential sulfidic leachate impacts. This may also require the analysis of total S on other locations to determine background levels.

We consider that the soil monitoring program requires further attention to resolve the deficiencies identified in the current and previous Independent Monitor audits. Considerable effort has been noted in the dust monitoring and management program, however unfortunately the same cannot be said for the soil monitoring program. We recommend the following improvements to the soil monitoring program:

- refine analytical suite and interpretation of data;
- increase spatial density of sampling program (at least every five years) or alternatively undertake delineation sampling of areas with increase metal concentrations; and
- importantly, develop site-specific trigger levels.

We consider the above recommendations highly feasible and it is unlikely that their implementation would require a significant cost, but rather time and dedication.

As with the dust monitoring review, the Independent Monitor considers it useful to provide an overview of the major issues identified over the years as well as the improvements by MRM to its soil monitoring program.

9.4.5 Overview of the past five years of soil monitoring

The first Independent Monitor audit undertaken in 2008 (for the 2006-2007 Operational Period) revealed one major flaw with regard to the interpretation of soil monitoring results: the use of NEPM (1999) health based soil investigation levels for commercial/industrial land use criteria for assessing results. Other issues identified included data gaps in the reporting of lead results and lack of interpretation.

The 2009 Independent Monitor audit (for the 2008 Operational Period) found some improvements in the presentation and interpretation of data collected for MRM's soil monitoring program. Nevertheless, some issues were noted such as the absence of QA/QC data, and the lack of interpretation for some parameters analysed such as pH and soil major

cations. The absence of site-specific triggers for heavy metals was also highlighted as an issue as MRM continued to use human health criteria for assessing soil results.

The Independent Monitor audit undertaken in 2010 (for the 2009 Operational Period) revealed concentrate-bearing dust on soil and vegetation on the banks of a tributary of Barney Creek. The audit also highlighted that the number of soil monitoring locations (25 at the time) could be considered insufficient given the large extension of the mining lease area. On a positive side, MRM improved the general reporting of results and provided complete laboratory documentation. No improvements were observed in other issues highlighted in previous audits e.g. deficient discussion of analytes and absence of assessments of long temporal trends. Specific methods for developing site-specific guidelines were proposed, as the misuse of the human health trigger levels continued.

The 2011 Independent Monitor audit (for the 2010 Operational Period) saw some improvements in the reporting of soil monitoring. These included the addition of background information for soils, provision of charts for selected locations and explanations for elevated levels. The small number of monitoring locations (23 at the time) compared to the large extension of the lease was again highlighted as an issue as this number of locations would not yield sufficient data to permit an accurate assessment of mine impacts. Significant fugitive dust was again observed emanating from the PACRIM with the potential to end up in nearby soils. MRM continued to use the human health HIL-F for assessing heavy metal concentrations in soil.

The current audit (2012 for the 2011 Operational Period) has seen a considerable improvement in the reporting of soil monitoring results and assessment, particularly by the adoption of the more conservative Environmental Investigation Levels (EILs) as trigger thresholds. It is noted however that only the 2010 Operational Period results were reported in the MMP due to the unexplained delay of monitoring results. There are also issues that need to be addressed by MRM both in terms of the monitoring of soil impacts and reporting, particularly the interpretation of laboratory result, as outlined in Section 9.4.4.

9.5 Review of fluvial sediment monitoring

9.5.1 Fluvial sediment monitoring program overview

According to the WMP 2011-2012 (MRM, 2011) a sediment monitoring program is conducted biannually at the mine site. Surface stream sediment samples are collected from each water monitoring location and then submitted for analyses for heavy metals/metalloids (arsenic, cadmium, copper, iron, manganese, lead and zinc); cations (calcium, potassium, magnesium and sodium); pH, electrical conductivity (EC) and particle size analysis (PSA). Sediment monitoring locations are presented in Figure 21 .

It is understood that only one round of results had been received at the time of writing of the latest WMP (MRM, 2011). Reportedly, the second round of sampling had been delayed due to a prolonged wet season and associated safety concerns. The results of the latest round of sediment monitoring have been nevertheless provided to the Independent Monitor and have been considered in this audit.

In general, it is considered that the fluvial sediment monitoring program undertaken by MRM is appropriate, and that it considers a reasonable number of sampling locations as well as a comprehensive laboratory analytical program. It is noted however that no sampling locations are being considered in the tributary south east of the Bing Bong Port facility. MRM have expressed that they consider sampling in the area to be sufficient, however, it is nevertheless

recommend that an isolated sampling event in the area to rule out any potential impacts in sediments.

Of particular note is MRM's commissioning of the study *McArthur River Freshwater Aquatic Macroinvertebrate Assessment 2011* (EMS, 2011). MRM is commended for undertaking this study to provide information as to whether any impact is occurring in local freshwater biota.

9.5.2 Review of fluvial sediment reporting

The fluvial sediment monitoring program results are discussed in Section 6.6 of the WMP 2012/2011 (MRM, 2011). As mentioned earlier, the WMP does not report on the latest samples for the 2011 Operational Period.

It is acknowledged that MRM have made improvements in the latest WMP, namely:

- providing background information as to the geomorphology and sedimentation regimes of the area;
- the overall improved presentation of laboratory results clearly identifying upstream and downstream locations at each stream being monitored (McArthur River and Barney Creeks and Surprise Creek);
- providing temporal heavy metal concentration charts and a discussion of trends for selected sampling locations; and
- providing an assessment of the potential causes of the elevated metal concentrations for particular locations.

Whilst MRM have shown improvement in the reporting of sediment monitoring results, there is however no discussion on results for major cations, EC, PSA or fine fraction (i.e. >63 µm) heavy metals in the WMP. This issue has been flagged in previous audits.

Figure 21 Fluvial sediment monitoring locations sampled by MRM. (Figure sourced from 2011/2012 WMP).

As in previous audits, complete laboratory transcripts with QA/QC documentation and accompanying chain of custody forms for fluvial monitoring have been received. No breaches to QA/QC procedures in the sampling or analysis process were noted. However, no field QA/QC section has been provided in the 2011/2012 WMP, therefore, it can only be assumed that complete procedures for QA/QC were not undertaken. This observation has been made in previous Independent Monitor audits.

It is noted that one of the objectives for the sediment monitoring program, as mentioned by MRM in the latest WMP, is to "*Compliment dust, soil and water monitoring programs as they all can be inter-related and provide an overview of environmental performance*". The Independent Monitor has not seen any correlation between sediment monitoring results in relation to soil and/or dust monitoring results in any WMP, and thus believes that this objective is note being achieved.

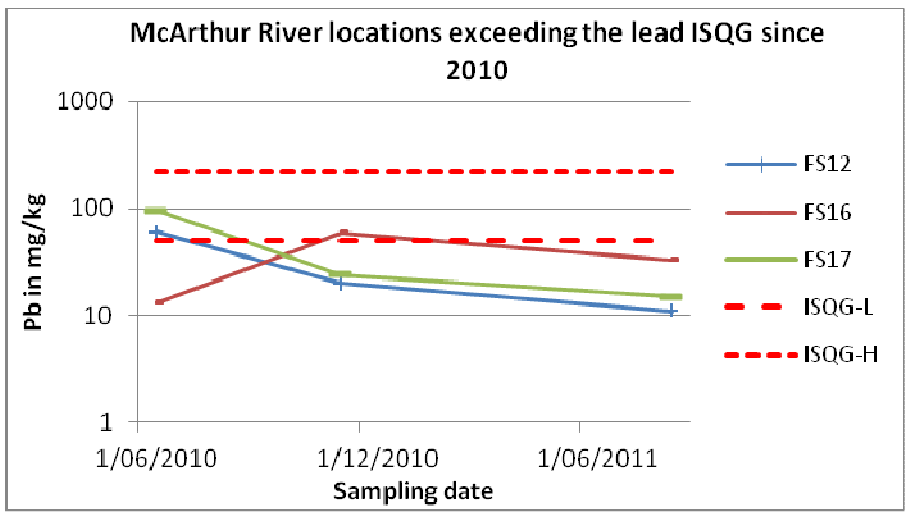
With respect to the fluvial sediment monitoring program findings reported by MRM, the data shows greater heavy metal impacts at downstream locations for all monitored streams (McArthur River, Barney Creek and Surprise Creek). The Independent Monitor agrees with the following observations made in the WMP:

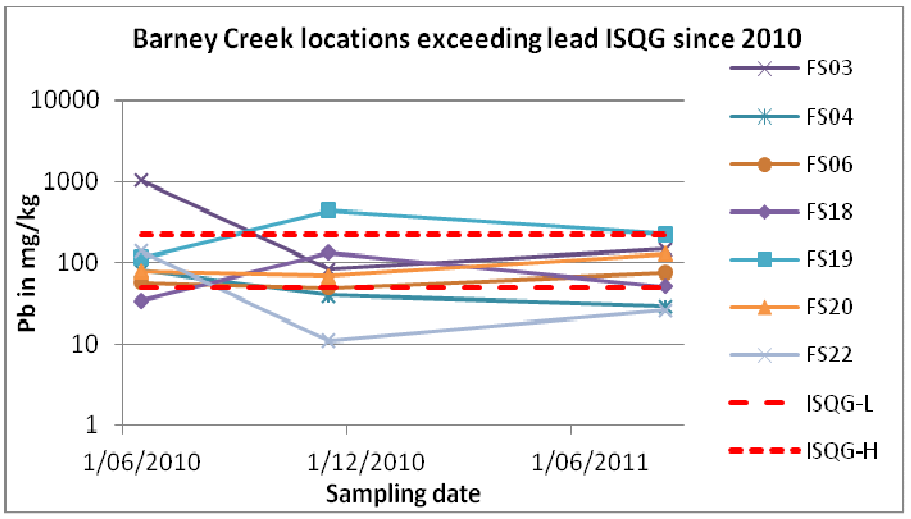
- neither McArthur River or Surprise Creek sediments seem to show major impacts in sediment heavy metal concentrations. Elevated concentrations have been however recorded in sediment collected from monitoring point FS2, located just downstream of the TSF in Surprise Creek;
- the statement made in the WMP of monitoring location FS04 having "naturally elevated (lead and zinc) concentrations" is believed to be made without sufficient supporting evidence. The fact that this location has recorded elevated leads and zinc concentrations in the past and that it is upstream of mine site influences, does not constitute sufficient grounds to make such a statement. It has to be noted that monitoring location FS04 is close to the Carpentaria Highway, which crosses Barney Creek so this area is prone to receiving concentrate-bearing dust dislodged from the road pavement by passing vehicles. This observation was also made in the previous Independent Monitor Audit reports (2010 and 2011); and
- it is also noted that MRM acknowledge the elevated heavy metal concentrations in sediments in Barney Creek, particularly in locations near Barney Creek Bridge. MRM also propose that these elevated levels are likely to be due to known issues associated with the Barney Creek Bridge and drainage off the NOEF Haul road. Further, MRM report that sedimentation basins have been constructed to address these elevated levels however that further measures may be required.

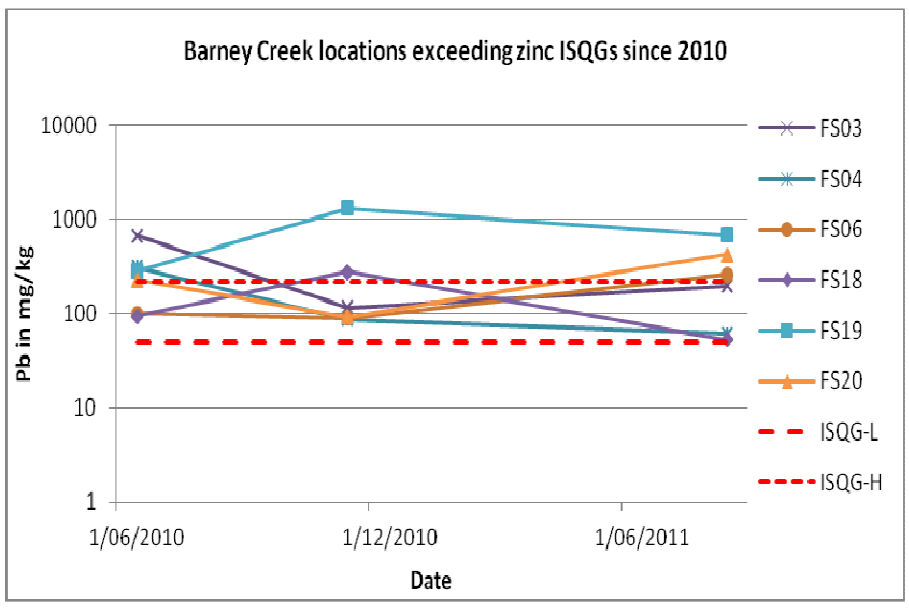
9.5.3 Review of fluvial sediment data

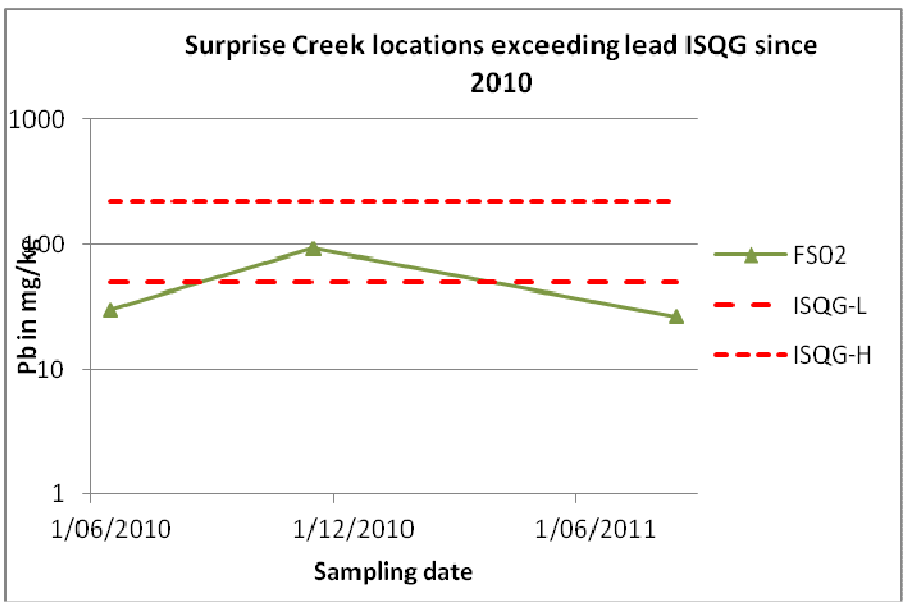
As expected, the highest metal concentrations for the 2011 monitoring were found in sediment samples from Barney Creek locations directly opposite and/or downstream of the mine site. Elevated lead and zinc concentrations were also found in one of the dams associated with the NOEF (monitoring point FSSPRD). Monitoring locations recording lead and zinc values above the ANZECC/ARMCANZ (2000) ISQG trigger values since 2010 are shown in the Figure 22 .

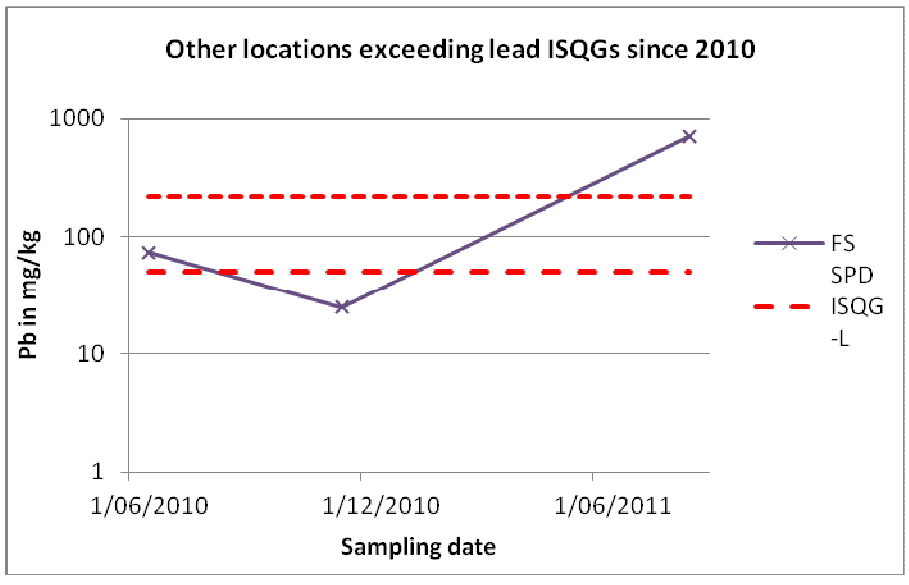
Depositional effects of contaminated sediment, or mineralisation effects as MRM suggest, are also observed downstream of McArthur River although concentrations seem to fluctuate, potentially due to variations in the flow regime.











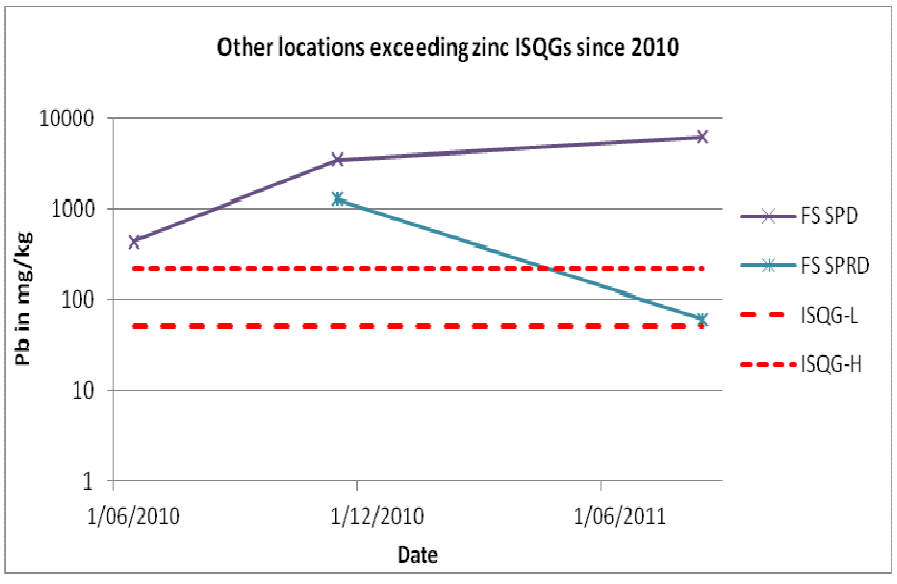


Figure 22 Fluvial Sediment Monitoring locations recording lead and zinc values above the ANZECC/ARMCANZ (2000) ISQG trigger values since 2010

Cadmium (Cd) and arsenic (As) concentrations above the ISQGs have also been recorded since 2010. On the latest round of monitoring (2011), the cadmium ISQG-L of 1.5 mg/kg and arsenic 20 mg/kg was exceeded in monitoring locations FS SPD (Cd: 6 mg/kg and As: 65mg/kg) and FS19 (Cd: 2 mg/kg and As: 27 mg/kg).

As mentioned earlier, MRM is aware of elevated metal concentrations in Barney Creek sediments (locations north of the mine-site FS3, FS18, FS19; and downstream locations FS20 and FS6) and plans further mitigation measures in this area. As mentioned in the WMP, these may include:

- investigate alternate options for drainage from the Barney Creek Bridge to prevent direct run-off; and/or
- preventative maintenance program aimed at minimising the potential sediment build up to enter Barney Creek prior to the 2011-2012 wet season.

9.5.4 Macroinvertebrate assessment – Fluvial sediment review

A macroinvertebrate assessment was undertaken in 2011, the results of which are provided in the *McArthur River Freshwater Aquatic Macroinvertebrate Assessment 2011* (EMS, 2011) report. This report is also summarised by MRM in Section 6.8 of the 2011/2012 WMP.

The investigation assessed freshwater aquatic macroinvertebrate as indicators of change in aquatic ecosystems in the vicinity of mining and diversion operations as well as the collection and analysis of fluvial sediment samples. Fluvial sediment laboratory results from this assessment have been reviewed by the Independent Monitor.

Surface sediment samples were collected from 33 locations distributed nearby the mine-site and vicinity and analysed for heavy metals / metalloids (As, Cd, Cu, Pb and Zn); cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}); pH and EC. Note that sampling included both locations nearby MRM operations and reference/background sites. Sampling locations are shown in Figure 23 .

Following review of the sediment results, the Independent Monitor makes the following observations:

- EC and pH values in locations nearby the mine are within the range of reference sites;
- cations are slightly to moderately elevated in mine-site locations with respect to reference sites; and
- metals and metalloids are generally higher in mine-site locations than reference sites, with some locations recording values above the ANZECC/ARMCANZ (2000) ISQG trigger levels (shown in Table 12 below).

As can be seen in Table 12 and Figure 22 , sediment monitoring points that recorded elevated heavy metals / metalloids concentrations were located in Barney Creek directly opposite MRM main operations (locations BC4 and BD5), and downstream in the McArthur River (locations MR15 and MR16). This is consistent with elevated concentrations that have been found at these locations during MRM's biannual sediment monitoring and also with the level of impairment found in macroinvertebrate communities downstream of the TSF.

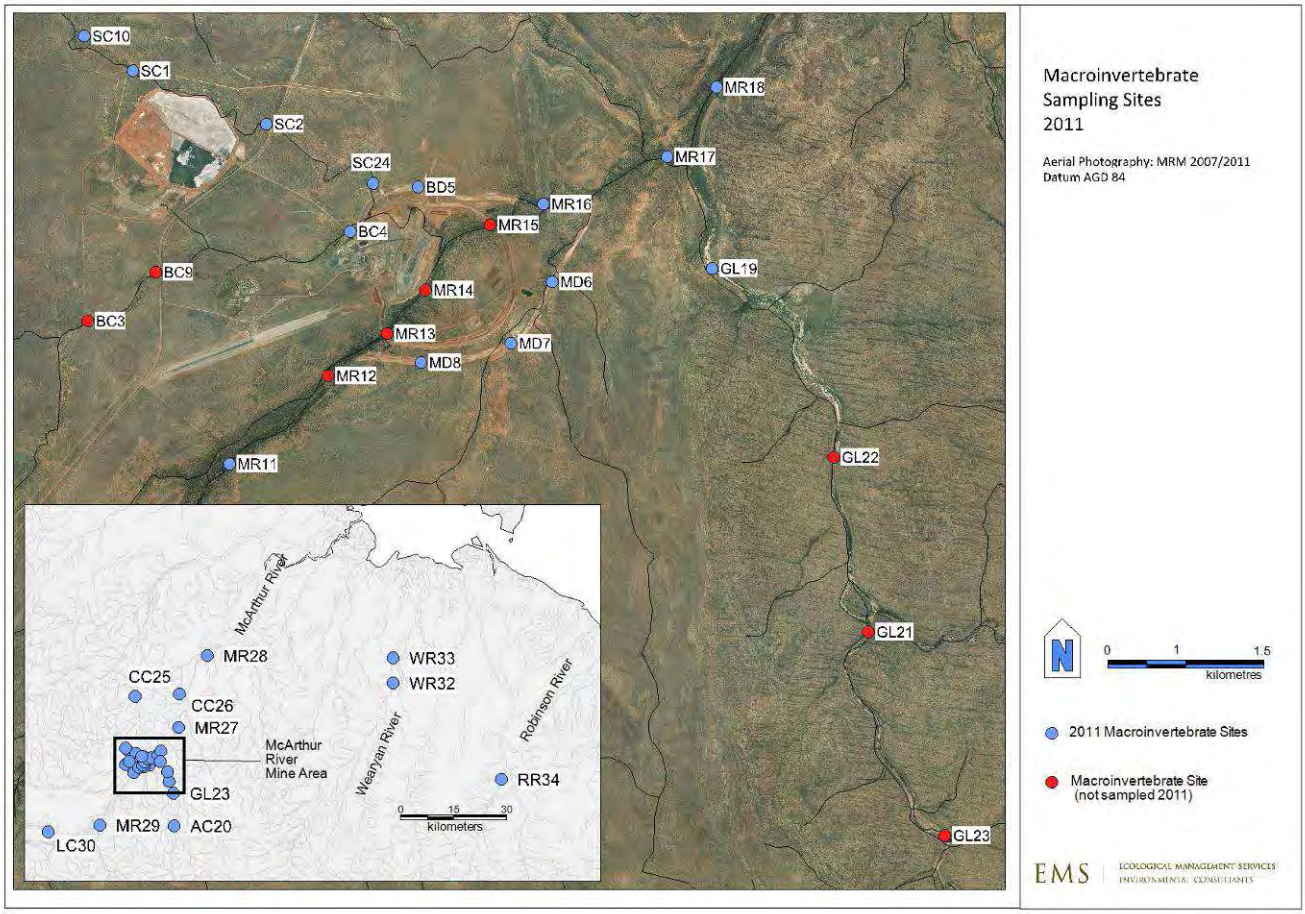


Figure 23 Fluvial sediment sampling locations undertaken by EMS as part of the Macroinvertebrate sampling in 2012. (Figure sourced from EMS, 2012a)

TABLE 12 SAMPLING LOCATIONS EXCEEDING ANZECC/ARMCANZ (2000) SEDIMENT TRIGGER VALUES

Sampling code	Description of location	Rationale	As	Cd	Cu	Pb	Zn
BC4	Lower Barney Creek above diversion	Exposed Processing - TSF	8	–	–	**132**	**133**
BD5	Barney Creek Diversion	BC Diversion/Exposed TSF	**26**	–	–	**134**	**523**
MR16	McArthur River between Barney Creek diversion outlet and the McArthur River Diversion outlet	Downstream MR	11	–	21	**100**	**345**
MR17	McArthur River Main Channel Downstream	Downstream MR	2.5	–	5	**82**	–
ISQG-L			20	1.5	65	50	200
ISQG-H			70	10	270	220	410

Notes: all concentrations in mg/kg.

Further, note that elevated heavy metals/metalloids concentrations (Table 12) are well above those recorded in sediment samples collected from reference sites, and thus are unlikely to be due to natural mineralisation of the area. Heavy metal / metalloids concentrations recorded in background/reference sites are provided in Table 13 below for comparison purposes.

TABLE 13 HEAVY METALS / METALLOIDS IN BACKGROUND LOCATIONS

Sampling code	Description of location	Rationale	As	Cd	Cu	Pb	Zn
SC10	Surprise Creek upstream of tailings	Reference/Baseline Minor Drainage Line	2.5	0.5	2.5	2.5	2.5
MR11	McArthur River Main Channel Upstream	Reference/Baseline Upstream MR	2.5	0.5	2.5	2.5	2.5
GL19	Glyde River lower	Reference Glyde River	2.5	0.5	2.5	2.5	2.5
AC20	Amelia Creek at Amelia Springs	Reference Minor Drainage Line	2.5	0.5	2.5	2.5	2.5
MR29	McArthur River upstream, below the Kilgour River confluence	Reference Upstream MR	2.5	0.5	2.5	2.5	5
WR32	Wearyan River	Reference Wearyan River	2.5	0.5	2.5	2.5	2.5
WR33	Wearyan River	Reference Wearyan River	2.5	0.5	2.5	2.5	2.5
RR34	Robinson River	Reference Robinson River	2.5	0.5	2.5	2.5	5

Notes: all concentrations in mg/kg.

9.5.5 Conclusions and recommendations

Elevated heavy metals in sediments may be having an effect in macroinvertebrate communities particularly in portions of Barney Creek. This is considered a serious issue, and MRM is encouraged to put into effect the planned mitigation measures at these areas. Further, the macroinvertebrate assessment (EMS, 2011) has also provided a good indication of the expected background metals concentrations in regional stream sediments. MRM should consider incorporating this information in its long-term targets, for example for closure planning.

There is also a general improved level of reporting in the WMP however some issues still remain (such as not reporting on data collected for particle size, pH and metal concentrations in fine fractions) which will aid in drawing the most accurate conclusions.

Key points for further improvement

- Address elevated concentrations within Barney Creek sediments by implementing the planned mitigation measures;
- include a discussion for all parameters analysed;
- include QA/QC samples (namely duplicates and splits) to add robustness to data; and
- incorporate background sediment levels determined by the macroinvertebrate assessment as long term targets.

9.5.6 Overview of the past five years of fluvial sediment monitoring

The initial Independent Monitor audit, undertaken in 2008 (for the 2006-2007 Operational Period) revealed data gaps in the reporting of monitoring data, as only lead and zinc results (and only for selected monitoring locations) were reported. Further, data interpretation was considered inadequate.

The subsequent audit (undertaken in 2009 for the 2008 Operational Period), showed improvement in the reporting and interpretation of fluvial sediments results compared to the previous year; however, some inconsistencies remained. The occurrence of several exceedances of adopted criteria and elevated metal concentrations in Barney Creek sediments was nevertheless flagged as an issue. It was deemed that these elevated concentrations were most likely mine related and influenced by dust fallout from the TSF and Rom Pad.

The 2010 Independent Monitor audit (for the 2009 Operational Period) saw improvements in the scope of sediment monitoring by the inclusion of samples at the Southern Potentially Acid Forming (PAF) dam. However, the absence of a sediment sampling locations in the tributary south east of the Bing Bong Facility was also noted. With respect to monitoring results, it was found that again metal concentrations within all monitored streams were elevated, particularly along the entire extension of Barney Creek with some locations recording lead levels above the ISQG-High trigger guidelines. Questions were also raised as to the lack of background data for sediments and a methodology for addressing this issue was proposed. Although improved from previous years, the reporting of results remained incomplete with several analytes not being reported.

The 2011 audit (for the 2010 Operational Period) revealed fur9.5.5ther improvements in the reporting of data with the inclusion of temporal concentration charts for particular locations and discussion of trends. Gaps were however still found with some analytes not being reported. It was also flagged that while some locations have consistently recorded elevated concentrations, MRM has not undertaken any toxicity testing as recommended by ANZECC/ARMCANZ (2000) guidelines. Further, it was proposed that sampling with a greater density was conducted nearby locations recording elevated heavy metals to determine whether remediation of these areas was required. The Independent Monitor also noted that no field QA/QC samples have been collected for the monitoring program.

This audit period, the Independent Monitor has recommended improvements in the reporting of data as outlined in Section 9.5.5.

9.6 Seawater and marine sediment monitoring program review

9.6.1 Overview of seawater and sediment monitoring

The marine monitoring program aims to assess whether activities at the Bing Bong Port facility are having a significant impact on sediments and seawater in the area. The main objectives of the seawater and sediment monitoring at undertaken by MRM, as specified in the WMP, are to:

- quantify the receiving environment water and sediment quality;
- quantify the extent of any impact on sediment and water quality in relation to the known characteristics of potential contaminants from the MRM operations at Bing Bong;
- establish routine surveillance monitoring programs to verify any future impacts on the marine environment; and
- provide information regarding the performance of the dust management strategies employed at Bing Bong.

The Independent Monitor agrees with the objectives set out by MRM for the sediment and seawater monitoring program however also recommends expanding the objectives to include establishing and assessing temporal and spatial trends in seawater and sediment quality.

As stated in MRM's latest WMP the marine monitoring program includes:

- routine monitoring of seawater and sediment carried out by MRM environmental personnel;
- specialist marine programs lead by Prof. Davis Parry, Australian Institute of Marine Science (AIMS);
- research activities in collaboration with Charles Darwin University (CDU) and AIMS; and
- target studies that have established has established background concentration (control sites) and statistical assessment of differences in metal concentration between sites.

Monitoring is undertaken by both MRM and the Australian Institute of Marine Science (AIMS) and the results of these investigations are found in the 2011/2012 WMP and the *McArthur River Mine: Annual Marine Monitoring Program* (AIMS, 2012).

Specifically, the marine monitoring program undertaken by MRM, as detailed in the latest WMP (MRM, 2011), includes:

- monthly sampling of eight seawater sample sites including two in the swing basin, three in the dredge channel and three at the control site;
- four seawater sampling locations using the diffusive gradients in thin-film (DGT) technique, which are deployed for a period of four to six days every month; and
- bi-annual marine sediment monitoring at seven locations including sites in the swing basin and dredge channel, and a reference site located at a distance away from the Bing Bong Port facility.

It was noted that a number of seawater sampling rounds were missed during 2011 and that only one sediment monitoring round was undertaken. This has been reported in the WMP (MRM, 2011x) to be due to inclement weather conditions and associated safety concerns.

The 2011 marine monitoring program undertaken by AIMS includes:

- sediment sampling at ten locations in the Bing Bong Port area;
- seawater, filtered and unfiltered, sampling at seven locations in the Bing Bong Port area;
- sediment and seawater sampling at seven locations in the Sir Edward Pellew Islands; and
- seagrass, gastropods and oysters sampling at Bing Bong and Sir Edward Pellew Islands.

Note that monitoring of seagrass, gastropods and oyster is discussed in Section 9.7.7 - 'Review of marine biota monitoring'.

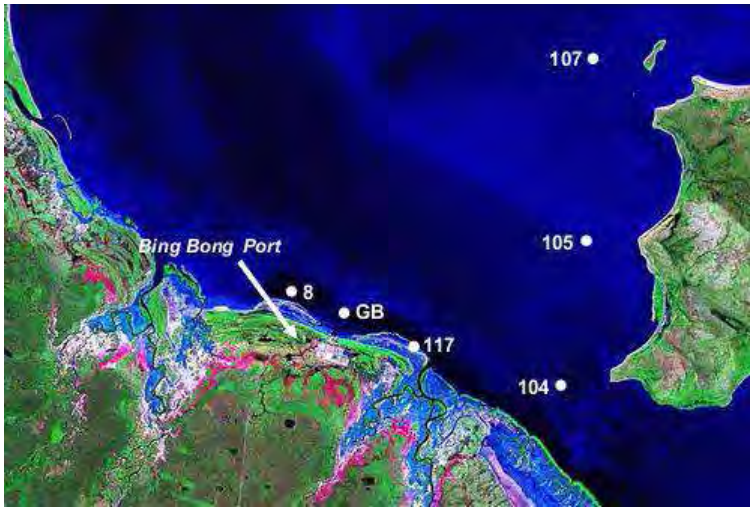
AIMS seawater and marine sediment sampling locations are shown in Figure 25 .

In addition, the AIMS undertook an investigation of seafloor sediments in the trans-shipment area. This report had not been released at the time of this audit.

The number and location of seawater and sediment monitoring locations is deemed appropriate, however, the Independent Monitor also notes once again the program does not consider the collection of samples from transects outside the swing basin.

MRM's monthly seawater and marine sediment sampling locations are shown in Figure 24 .

Figure 24 MRM sampling locations for seawater and sediment at Bing Bong Port. (Figure sourced from 2011/2012 WMP).



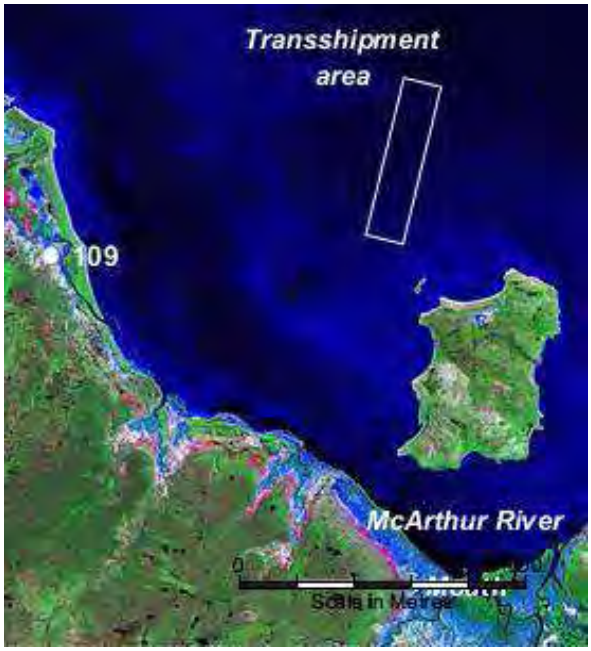


Figure 25 Annual AIMS seawater and marine sediment sampling locations. (All figures sourced from *MRM Annual Marine Monitoring Program 2011* Report, AIMS, April 2012)

9.6.2 Review of seawater and sediment monitoring reporting

A considerable improvement in the clarity and organisation in the presentation of the seawater and marine sediment monitoring program has been noted in the latest version of the 2011/2012 WMP. The Independent Monitor particularly notes:

- appropriate objectives set out for the programs;
- clear depiction of sampling locations;
- separation in the presentation of results by interest area (i.e. control sites, navigation channel and swing basin);
- explanations on the selection of set trigger levels;
- comprehensive depiction of trends by location for seawater monitoring;
- discussion of results for DGT monitoring;
- accounting for missed sampling rounds; and
- discussion of potential sources and correlation of sediment data.

The excellent presentation and discussion of results undertaken in the latest Annual Marine Monitoring program undertaken by AIMS (2012) is also noted.

Some issues however remain from the previous Independent Monitor audits:

- no presentation of temporal trends for sediment monitoring was found. It is understood that sediment monitoring was only undertaken in one occasion, however this does not prevent the presentation of these results along with previous monitoring rounds;
- the WMP does not mention whether the seawater samples collected as part of the monthly seawater monitoring program undertaken by MRM correspond to unfiltered or filtered samples. Inspection of internal MRM documentation revealed these results to correspond to unfiltered samples. Whilst the ANZACC/ARMCANZ (2000) guidelines advise that unfiltered samples can be utilised for assessment of water quality, it is recommended that if any exceedances are recorded then the following round both a filtered and unfiltered sample be collected at the location;
- once again, no QA/QC results were provided to the Independent Monitor for any of the programs undertaken by MRM and thus it is assumed that this was not undertaken; and
- QA/QC analyses results were provided in the reports undertaken by the AIMS (mainly reference materials and duplicate samples) however no discussion was provided. analysis of the data by the Independent Monitor noted that results QA/QC results were generally within acceptable ranges.

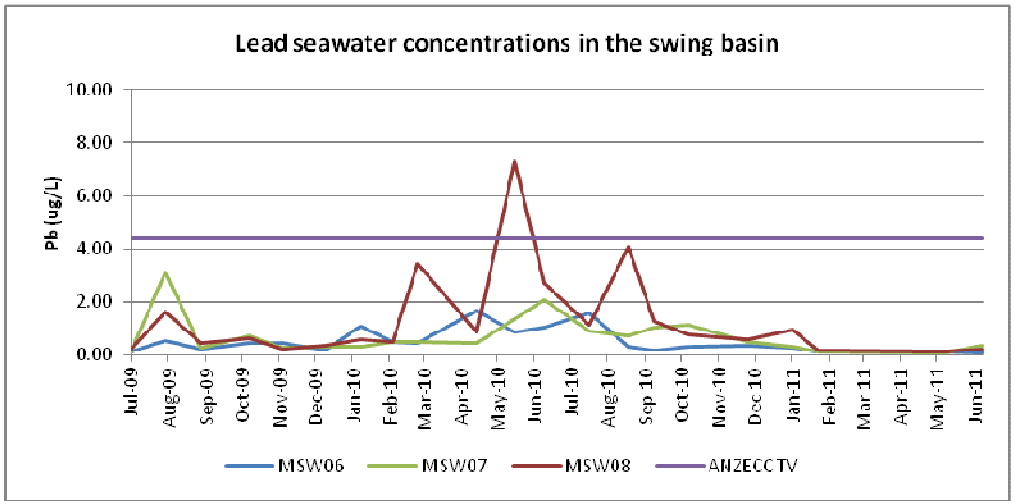
9.6.3 Review of seawater and sediment monitoring data

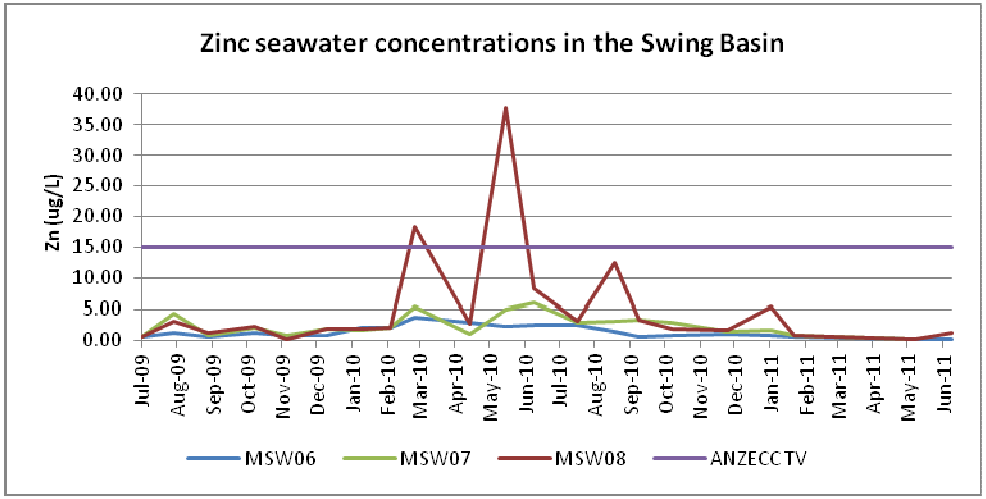
Upon review of the data collected, the Independent Monitor makes the following observations:

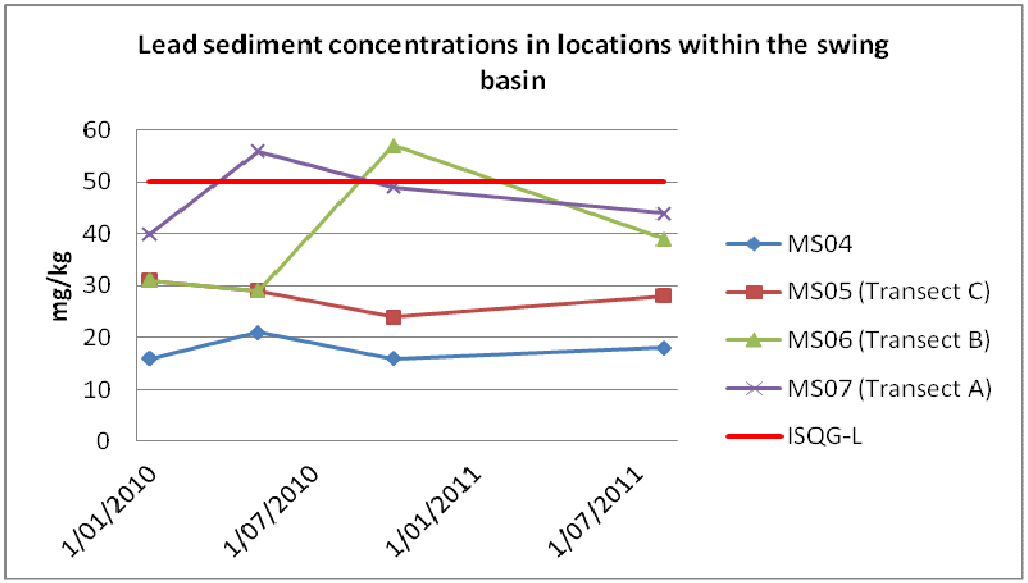
- in general, lead and zinc results for both seawater and sediments recorded higher concentrations in the swing basin site as opposed to the control sites, indicating an impact from mining operations. Lead isotope analysis undertaken on sediment at a beach site west of the Bing Bong facility also revealed an MRM ore impact (isotopic lead signature) in lead concentrations;

- lead isotope analysis of suspended sediment at the McArthur River delta and Sir Edward Pellew Islands was again not undertaken by MRM in the 2011 Operational Period;
- all seawater results were below the ANZECC/ARMCANZ (2000) threshold for the protection of 95% of the species and generally showed a noticeable decrease when compared to last year's results;
- all sediment results recorded metal concentrations below the ANZECC/ARMCANZ (2000) ISQG-Low during the 2011 monitoring (one round). Metal concentrations also showed a decrease with respect to previous years;
- MRM mention in the WMP that improving the effectiveness in source control of contaminants will not be noticeable in sediment heavy metal concentrations due to the reportedly low depositional rate of cleaner material, and that this process may take "decades or more". The Independent Monitor is in disagreement with this statement and cautions MRM not to drive management measures by this statement as it may lead to complacency. Further, as noted above, no exceedances of the ANZECC/ARMCANZ (2000) ISQG-Low triggers were recorded potentially indicating that mitigation measures at Bing Bong are being effective and noticeable; and
- with respect to the above point, MRM is also advised that there are techniques for determining sedimentation rates and concentrations over time (such as push-tube sediment coring). This has been mentioned in previous Independent Monitor audits (Environmental Earth Sciences, 2010).

Charts depicting seawater and sediment concentrations are shown for locations near the swing basin are provided in Figure 26 .







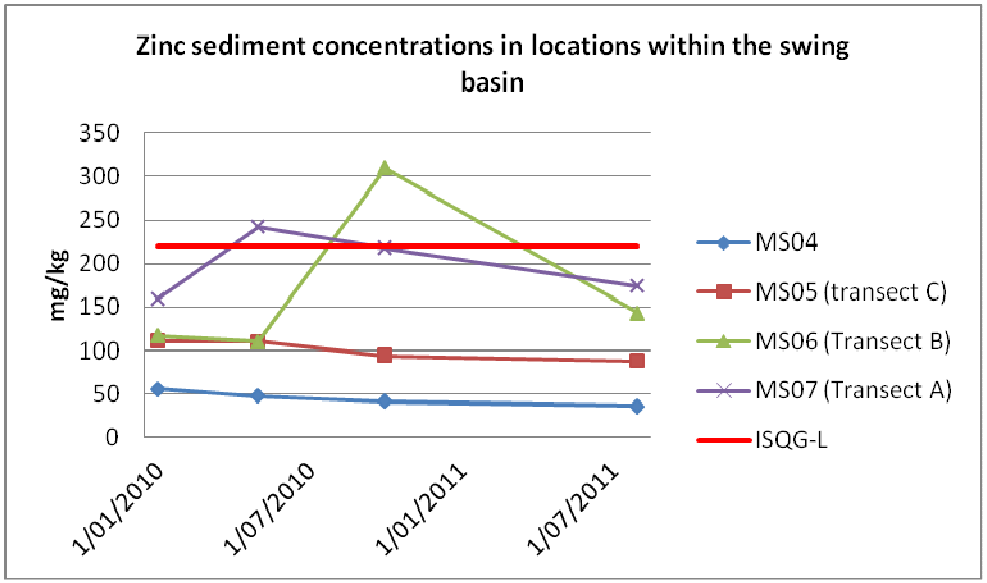


Figure 26 Temporal charts showing seawater and sediment concentrations at locations near the swing basin at Bing Bong Port.

9.6.4 Diffusive Gradients in Thin-films seawater monitoring

The Australian Institute of Marine Science (AIMS, 2012) undertook analysis of the data collected during May 2011 to April 2012 as part of the Diffusive Gradients in Thin-films (DGT) seawater monitoring program. The DGT monitoring provides information as to the exchangeable portion of heavy metals in seawater and thus acts as a proxy for the potential bioavailable fraction. Sampling locations are depicted in Figure 27 and Figure 28 below.

Figure 27 DGT sites 1 and 2 west and east of the channel, respectively, and DGT site 3 in the south east corner of the swing basin. (Figure source: AIMS, 2012)

Figure 28 DGT site 4 in the swing basin. (Figure source: AIMS, 2012)

According to the AIMS DGT report, the most significant findings of the program were as follows:

- at sites east and west of the channel in 2011-12, concentrations of DGT-labile Pb, Zn, Cd, Cu and Ni were all less than their respective ANZECC (2000) water quality trigger value, for 99 % species protection (applicable to pristine environments) in marine water;
- the swing basin contained concentrations of DGT-labile Pb, Zn, Cd, Cu and Ni that were generally less than their respective ANZECC (2000) 99 % protection level. The exceptions were Ni on one occasion and Cu during three samplings; when concentrations of these metals were greater than their 99 % protection level, but less than their 95 % protection level; and
- lead isotope ratios at monitoring sites to the east and west of the channel were occasionally elevated, which is attributable to dispersion of dissolved Pb from the swing basin. However, DGT-labile Pb concentrations at channel sites and in the swing basin remained below the ANZECC (2000) 99 % protection level; therefore would be protective of the environment along the Bing Bong coast. This was also the case for bioavailable Zn.

Whilst the Independent Monitor is in general agreement with these conclusions, several inconsistencies and anomalies were also reported, such as:

- on occasions, filtered zinc recorded higher concentrations than dissolved zinc;
- low correlation between primary samples and duplicates;
- bio-fouling on some sampling locations; and
- no verification as to whether DGT devices were cleaned thoroughly.

In light of the above issues, it is believed that the reliability of the data collected is not sufficient to make definitive conclusions as to the water quality at Bing-Bong. It is nevertheless believed that DGT monitoring is a very useful tool, and MRM is encouraged to put in place more stringent QA/QC methods for minimising anomalies due to cross-contamination during either sampling and/or laboratory analysis.

9.6.5 Annual Marine Monitoring (seawater and sediments)

The Independent Monitor has also reviewed the sediment and seawater data contained in the AIMS (2012) Annual Marine Monitoring program and agrees with the main conclusions of this report. These have been transcribed below:

- physicochemical parameters and dissolved and total metal and arsenic concentrations in seawater along the Bing Bong coast and Sir Edward Pellew Islands were at natural background levels. In addition the metal concentrations were at or substantially lower than the ANZECC (2000) default trigger values for 99% protection;
- similarly, surface sediment metal and arsenic concentrations and Pb isotope ratios in the Bing Bong coastal area and Sir Edward Pellew Islands were at natural background levels and were at or substantially below the ANZECC (2000) Interim Sediment Quality Guideline-Low Concentrations of Cu, Zn, Cd and Pb. In the Bing Bong eastern beach sediment values were higher than those reported for 2010 sediments; and
- the beach site immediately west of the loadout facility had elevated levels of Zn, As, Cd and Pb in the surface sediment with the Cu, Zn and Pb concentrations lower than in previous years. Although these concentrations are elevated they are still lower than the ANZECC (2000) ISQG-Low values. Lead isotope ratios confirmed that the Pb in western beach sediment is derived from the MRM ore concentrate.

9.6.6 Conclusions and recommendations

The considerable improvements in the presentation and assessment of data by MRM in the latest WMP are a testament of both MRM's commitment to improving their environmental standards and the effectiveness of the Independent Monitor program. It is also believed that MRM are currently achieving the objectives set out for the seawater and sediment monitoring programs.

With respect to potential seawater and sediment contamination at the area due to MRM activities, the Independent Monitor has noted that concentrations have either decreased or remained below levels of concern most likely reflecting the improvements in the management of dust at Bing Bong. It is expected that with the further planned improvements for the management of fugitive emissions from Bing Bong heavy metal concentrations in seawater and particularly sediments within the swing basin decrease even further.

Recommendations

Key recommendations for further improvement of the seawater and marine sediment monitoring program are outlined as follows:

- include QA/QC samples (namely duplicate and splits) in the regular seawater and sediment programs;
- upgrade DGT monitoring QA/QC procedures;
- include presentation of trends for sediment monitoring results;
- include assessment of sediment samples from transects outside the swing basin; and
- include lead isotope analysis of suspended sediments from the water column in the McArthur River delta region.

9.6.7 Overview of the past five years of seawater and sediment monitoring

The 2008 audit (for the 2006-2007 Operational Period) found that fugitive emissions at Bing Bong were likely to have resulted in elevated concentrations of metals, particularly zinc, in the beach sediments around the swing basin. Assessment of data revealed impact in beach sediment up to 400 m west of the load-out facility but not more than 200 m east. Levels found were significantly elevated and clearly associated with the activities of the load out facility but below the ANZECC (2000) ISQG – Low guidelines. Studies of lead isotopes of particulates in the water column delineated the lead as being from the McArthur River ore body. The Independent Monitor also highlighted the importance of protecting the undisturbed environment of the area.

The following audit, undertaken in 2009 for the 2008 Operational Period found decreased lead and zinc concentrations in the water column, however elevated levels in locations close to the swing basin were also recorded. Reporting and interpretation of seawater and sediment monitoring results was found to be deficient (and contravening MRM commitments) as it omitted several analytes. Stable to increasing concentrations of heavy metals in the swing basin and shipping channel sediments, particularly closer to the load-out facility were noted. These increases over time indicated fugitive dust emissions and concentrate handling deficiencies. Build-up of heavy metal concentrations in sediments was found since the last time the channel had been dredged confirming the impact of fugitive dust emissions and ore concentrate handling processes. MRM was also reminded of the importance of undertaking lead isotope analysis (absent on this occasion) to gain information regarding the source of elevated lead levels.

In the 2010 audit (for the 2009 Operational Period), the Independent Monitor highlighted improvements to the seawater monitoring program such as establishing control sites, statistically assessing differences in metal concentrations between sites and extra sediment

monitoring locations. As with previous years, the highest lead and zinc concentrations were recorded in monitoring locations nearby the port, however no major impact of mining operations was determined on seawater conditions. It was noted that potential for pollution reaching the McArthur River Delta existed and thus monitoring of this area was recommended. The Independent Monitor also recommended the collection of sediment samples from transects outside the swing basin.

As with previous years, the 2011 audit (for the 2010 Operational Period) noted the highest sediment and seawater lead and zinc concentrations in samples close to the port. Lead isotope analyses undertaken on sediment at a beach site west of the Bing Bong facility also revealed an MRM ore impact. In addition, elevated nickel concentrations above the ISQG-L trigger were found in marine sediment. A number of issues were noted with regard to MRM's seawater and sediment monitoring program such as the lack of presentation of DGT results, absence of QA/QC results and long-term trends. The Independent Monitor once again recommended the collection of sediment samples from transects outside the swing basin.

This audit period, the Independent Monitor has observed considerable improvements in the seawater and marine sediment monitoring program mainly in the presentation and discussion of data within the 2011/2012 WMP. The Independent Monitor is pleased to see that many of the recommendations put forward with regard to the presentation and assessment of data over the years have been implemented.

9.7 Review of Flora and Fauna Monitoring

9.7.1 Overview of flora and fauna monitoring

This section provides a review of flora and fauna monitoring and management documentation from MRM carried out during the 2011 Operational Period. It also incorporates observations made during the Independent Monitor's site inspection on 28-29 May 2012.

Rehabilitation and monitoring at McArthur River Mine is largely moving in a positive direction with significant improvements noted since the first Independent Monitor audit was completed in 2008. Significant improvements in the 2011 Operational Period included increased vegetation cover along the McArthur River and Barney Creek diversion channels. The indicator species Purple-crowned Fairy-wren was recorded for the first time entering the Barney Creek rehabilitated riparian area during riparian bird surveys, which serves as an indication that the revegetated area is beginning to resemble that of a natural riparian habitat. It is pleasing to see that the intensive weed control has continued in 2011, and has had a noticeable effect on populations of Parkinsonia at the Bing Bong dredge spoil ponds.

Although improvements have been made, some important recommendations from the previous year have not yet been implemented by MRM, creating monitoring gaps in some areas. In particular, vegetation monitoring along the river diversions has not yet been expanded along the McArthur River to cover the entire diversion, and MRM is yet to establish a suitable reference site for Barney Creek revegetation. Control sites also remain absent from the seagrass monitoring program, which is an aspect that is necessary to be able to correctly interpret causes and trends in seagrass distribution. Further areas of concern are discussed below and recommendations are attached to each section.

All required monitoring commitments relating to flora and fauna monitoring were found to be completed during this Operational Period (as per commitments in the 2010/2011 MMP and 2011/2012 MMPs)

9.7.2 Improvements since the previous Operational Period

The following improvements have been made to flora and fauna monitoring at the Mine site since the previous Independent Monitor audit:

- over 15,000 tubestock planted along the McArthur River diversion including significant efforts put into rehabilitating the opposite bank of the McArthur River diversion;
- an extra 3000 tubestock planted along the Barney Creek diversion;
- a sled watering system installed on the opposite bank of the McArthur river diversion and has resulted in a noticeable increase in vegetation growth compared to unwatered areas;
- successful propagation of Freshwater Mangrove *Barringtonia acutangula* and Native Cane Grass *Chionachne cyathopoda* at the MRM plant nursery;
- the construction of a greenhouse at MRM plant nursery with the capacity of holding 40,000 seedlings;
- the addition of a further three large woody debris piles in the McArthur River diversion with monitoring conducted on movement of fish and use of all large woody debris in the diversions;
- the relocation of the cattle exclusion fence along the McArthur River diversion to higher ground resulting in less damage to fencing and fewer repairs being needed. The remaining fencing was repaired during the 2011 dry season;
- mustering of cattle out of the operational areas occur in 2011 and 2012 but continues to be a challenge;
- the Purple-crowned Fairy-wren was recorded within the continually developing riparian shrubby woodland vegetation on the Barney Creek diversion;
- Freshwater Sawfish were recorded both upstream and downstream of the MRM with one recorded free swimming in the McArthur River diversion;
- intensive weed control was carried out particularly on patches of Parkinsonia but also tackling Noogoora Burr, Bellyache Bush, Devils Claw and Mission Grass;
- monitoring of riparian birds, migratory birds, fish, macro-invertebrates, rehabilitation of diversions, metals in marine biota and seagrass were all carried out within the 2011 Operational Period as per commitments. Most were carried out satisfactorily with some suggestions included below;
- sowing of native grass seed inside the mine pit wall with an irrigation system installed allowing pit water to be recycled;
- re-seeding with native grasses conducted at the tailings storage facility (TSF) cell 1 and Bing Bong dredge spoil ponds; and
- clearing and reshaping was carried out on the Bing Bong dredge spoil ponds spoon drain allowing saline seepage on the ponds to be directed away from surrounding vegetation and back out into the sea.

9.7.3 Mine site terrestrial flora monitoring

McArthur River Diversion vegetation monitoring

Annual vegetation monitoring on the McArthur River diversion was carried out by Charles Darwin University (CDU) in July 2011 with the aim of assessing the success of the restoration of the riparian areas along the McArthur River diversion compared with the undisturbed areas along the Mcarthur River (CDU, 2011). CDU examined three plots along the diversion with each plot incorporating the bank slope and area above the batter at the top

of the bank. The survey evaluated the survival of plant stock along with growth and density of vegetation at each plot. One site was planted with tubestock in 2010 while the remaining two sites were direct-seeded in 2007-2008 (CDU, 2011). The survey found that the establishment of plants from seeds resulted in a higher density than that resulting from tube stock (survival rate of 45% since 2010). Surviving individual plants have increased significantly in height and natural since 2010, and some natural recruitment was also observed at the McArthur River Diversion sites (CDU, 2011).

In 2011, the Independent Monitor recommended that the vegetation monitoring carried out by CDU on the McArthur River diversion be expanded along the entire length of the channel. This was not completed in the 2011 Operational Period but is expected to be incorporated in the 2012 Operational Period, if variability of flood conditions allows (G. Taylor, pers. comm., 2012).

The McArthur River diversion was visited by the Independent Monitor at the end of May 2012, with a greater area inspected than in previous years. The Independent Monitor observed significant improvement of the vegetation community along the diversion particularly along the opposite bank where MRM have dedicated substantial efforts in rehabilitation (Plate 7).

In addition to the water sled positioned on the mine side bank (commitment 92, 2010/2011 MMP) a second water sled has been installed on the opposite bank of the diversion, as advised in 2011 by MRM during the previous inspection (G. Taylor, pers. comm, 2011). The vegetation has responded positively to this addition and the density of plants in the irrigated area has increased noticeably compared to the previous year and compared to adjacent unirrigated areas.

As per commitment 100 (2010/2011 MMP), MRM sourced plants for rehabilitation in 2011 from the Ironstone Lagoon Nursery and the Darwin Plant Wholesalers. In addition, propagation of plants occurred in the onsite nursery including *Barringtonia acutangula, Melaleuca argentea* and *Eucalyptus camaldulensis* (MRM 2010/2011 propagation register).

According to the McArthur River diversion planting register, 1,207 tubestock individuals were planted between the 15th February 2011 and 2nd March 2011 along the mine side of the river. Species planted included mostly River She Oak *Casuarina cunninghamii*, River Red Gum *Eucalyptus camaldulensis* and *Melaleuca argentea* with some Tall Tamil Grass *Chrysopogon elongatus* and Native Cane Grass *Chionachne cyathopoda*.

In the October/November 2011, extensive tubestock planting was conducted on the opposite bank of the McArthur River with approximately 10,100 individuals planted. Species included *Casuarina cunninghamii*, *Eucalyptus camaldulensis*, *Terminalia platyphylla*, *Corymbia bella*, *Melaleuca sp*. and some *Acacia sp*. and *Nauclea orientalis* (2011 McArthur River Planting Register).

As recommended in the previous Independent Monitor report (for the 2010 Operational Period), MRM should focus on achieving a species diversity which more closely resembles the original river channels including the key species, Freshwater Mangrove *Barringtonia acutangula* and Native Cane Grass *Chionachne cyathopoda*. These species were again almost absent from tube stock planting in the 2011 Operational period. No *Barringtonia acutangula* were planted and only 23 Native Cane Grass (2011 McArthur River Planting Register). The Independent Monitor understands the difficulty in cultivating these species and is encouraged by the successful propagation of many *Barringtonia acutangula* from seed in the MRM nursery observed during the site inspection. These individuals will be planted in 2012 (Taylor, G., pers. Comm. 2012). A new green house has also been constructed at the

MRM plant nursery with the capacity of holding up to 40,000 seedlings (G. Taylor, pers. comm, 2012) (Plate 9).

Good vegetation cover was observed at the top of the slopes along the mine-side of McArthur River diversion towards the McArthur River/Barney Creek confluence. No direct seeding or planting has occurred here and MRM informed the Independent Monitor that the vegetation cover is likely a result of seed being washed downstream from rehabilitation works by MRM further upstream (J. Crawford, pers. comm, 2012). (Plate 8)

It is acknowledged that MRM have two main objectives when rehabilitating the banks of the McArthur River diversion, with the first being to establish a natural vegetation community on the slopes (commitment 90, MMP 2010/2011 (MRM, 2010)) while the second aims to establish vegetation along a 20 metre wide strip above the batter slope (commitment 91, MMP 2010/2011 (MRM, 2010)) to allow the transition of the slope community into the undisturbed vegetation above (2010/2011 MMP, MRM, 2010, p. 147). While the revegetation of the diversion is encouraging it is noted that the majority of planting has been carried out on the flat plain area (above the batter slope) bank leaving much of the slopes bare. The Independent Monitor understands that the revegetation of the slopes is difficult due to flooding and presence of rocky substrates. In 2012, efforts should be concentrated on achieving vegetation cover on the slopes and since depositional areas are starting to appear on the sloped areas due to natural obstructions to water flow, these areas could be practical focal points for additional revegetation efforts.

In January 2011, MRM carried out a tree planting trial in which they investigated the survival of tube stock during wet season conditions, a low number of *Eucalyptus camaldulensis* and *Casuarina cunninghamii* were used (MRM, 2011e). The tube stock was placed in areas at the top of the bank where minimal flooding occurs, ensuring maximum chance of survival. The results of this trial were not provided. The Independent Monitor would like to see this trial expanded to include a range of riparian plants and the trial plots occurring at different levels on the bank slope. This will help to identify plants which are more likely to survive in areas of higher stress (for example at lower areas of the bank slope) allowing MRM to conduct selective species planting in future. The trial would not have to involve large numbers of tube stock and would save costs in relation to lost tube stock in the long run.

During the Independent Monitor site inspection, significant erosion was identified along the McArthur River diversion due to the lack of vegetation cover in some areas. In time with increased rehabilitation works this should improve. (Plate 10)

Plate 7 Photograph taken during the May 2012 site inspection showing sled watering system and good vegetation cover on the opposite bank of the McArthur River diversion. Photo: Independent monitor.

Plate 8 Downstream area of McArthur River diversion in 2012 with vegetation coverage above batter on mine side in background. Vegetation growth likely due to seed being washed downstream from rehabilitation areas further upstream. Photo: Independent monitor.

Plate 9 Newly constructed second greenhouse at MRM plant nursery which will hold 40,000 tubestock. Photograph: Independent monitor.

Plate 10 Erosion on mine side of McArthur River diversion. Photograph: Independent monitor.

Barney Creek vegetation monitoring

MRM is required to rehabilitate Barney Creek under commitments outlined in the 2010/2011 MMP (MRM, 2010). They are also committed to "Continue the assessment of rehabilitation establishment to determine rehabilitation success and to identify any mitigation strategies

that may be required (Commitment 29)" and under commitment 30 to "conduct further rehabilitation activities in the McArthur River channel and Barney Creek" (2010/2011 MMP, MRM, 2010).

Monitoring of the Barney Creek vegetation was conducted in July 2011 by CDU. Three plots were again surveyed for survival, growth and density (CDU, 2011).

Mortality of plants has decreased substantially since July 2010. In 2011, only 12 tube stocks were found to have died with the cause most likely being water stress (CDU, 2011).

Eucalyptus camaldulensis continues to exhibit the highest survival of the species planted. *Casuarina, Lophostemon, Melaleuca* and *Terminalia* tube stock which experienced high mortality in the early years after planting have now established well, experiencing little to no mortalities in 2011 (CDU, 2011).

Grass survival has continued to decrease (CDU, 2011). Some Native Cane Grass was planted in 2011, although planting occurred in low numbers (23, 2011 MRM seed register). Due to the high mortality exhibited by grasses, the Independent Monitor recommends that further attention is concentrated on the propagation of grasses and planting of higher numbers as tube stock in future.

In 2011, The Independent Monitor recommended that the actual data versus baseline and analogue sites data for Barney Creek should be expanded in the annual revegetation monitoring reports (EES, 2011). Although the most recent report of the revegetation of Barney Creek contains additional comparison, it is minimal, and the Independent Monitor recommends that this section is developed further in future reports.

As mentioned in the previous two Independent Monitor reports (EES, 2011, EES, 2010), additional appropriate analogue sites are required for vegetation monitoring on Barney Creek. The current analogue site for Barney Creek is situated on Surprise Creek, which is a different system to Barney creek and is downstream of tailings seepage problems and therefore unsuitable. The addition of these sites is yet to be added to the survey design. MRM have responded to this recommendation stating "new sites should be established during the 2012 survey depending on access".

MRM should consider conducting metal analysis on vegetation in McArthur River and Barney Creek to monitor uptake of metal resulting from mining operations.

The vegetation on the Barney Creek diversion continues to progress, exhibiting good vegetation cover with, in particular, tall E. camaldulensis observed (over 10 metres tall) and a vegetation community of varying maturities (Plate 11 and Plate 13)

MRM have planted an additional 2959 tube stocks on 9.49 hectares focusing on the lower regions of Barney Creek and the flatter areas at the top of the batter (MRM 2011a, MRM 2011d). Tube stock used consisted mostly of *E. camaldulensis* with some *Casuarina cunninghamii, Chrysopogon elongatus and Chionachne cyathopoda.*

The Independent Monitor is satisfied that MRM is meeting commitments in terms of monitoring and rehabilitating of Barney Creek but that some additional survey could be carried out and improvements should be made to the survey design of vegetation monitoring to improve the quality of results.

Plate 11 Upstream view of Barney Creek/Surprise Creek confluence, May 2012. Photograph: Independent monitor

Plate 12 Upstream view of Barney Creek/Surprise Creek confluence, May 2011

Plate 13 Downstream view of Barney Creek/Surprise Creek confluence, May 2011.

Plate 14 Downstream view of Barney Creek/Surprise Creek confluence, May 2012.

Figure 29 Area planted along Barney Creek in 2011. (Figure sourced from MRM Rehabilitation Jan-June 2011 document).

2009

2010

2011

2012

Plate 15 Photographic comparisons of revegetation along the upstream area of the Barney Creek diversion channel (facing upstream). Photographs taken by the Independent Monitor in 2009-2012 during the annual Dry Season mine site inspections.

2008

2009

2010

2011

2012

Plate 16 Photographic comparisons showing five years of revegetation Barney Creek Diversion – Surprise Creek confluence.

Review of Weed Management

MRM is required to conduct weed control on operational areas as per the Weed Management Plan (MRM, 2011c).

According to the Weed Management Plan (MRM, 2011c), weed control in the 2011 Operational Period was carried out on weed species Devils Claw *Martynia annua,* Noogoora Burr *Xanthium strumarium occidentale*, Bellyache Bush *Jatropha gossypiifolia*, Parkinsonia *Parkinsonia aculeata* and Annual Mission Grass *Cenchrus pedicellatus* (see Figure 30).

A large area adjacent to the old McArthur River Homestead was aerial sprayed in April 2011 to combat an infestation of Devils Claw. Spraying was not thought to have been as successful as that conducted in the previous year due to weeds undergoing stress at the time of spraying. Further spraying is planned in 2012 (MRM, 2011c). Some hand-pulling and foliar spraying was also carried out along the McArthur and Barney Rivers, at the airport and within the mine pit levee wall (MRM, 2011c).

Noogoora Burr weed control was carried out in 2011 along approximately half of the mine side of the McArthur River diversion via back-pack spraying. MRM plans to conduct spraying along the remainder of the diversion in 2012 (MRM, 2011c). During the May 2012 site inspection, the Independent Monitor observed Noogoora burr along both sides of the McArthur River diversion. Weeds were found to be in higher densities on the opposite bank of the diversion due to weed control efforts being concentrated on the mine side (G. Taylor, pers. comm. 2012).

Bellyache Bush is removed at MRM through hand-pulling and selective spraying. Large areas of infestation are burnt annually. Areas treated during 2008 and 2009 were inspected with surviving plants being hand-pulled. An area previously identified at the old McArthur River homestead is believed to have been eradicated and a small infestation found at the back of the camp accommodation was removed and burnt. Another small population was identified at the contractor's camp; this was also removed by hand-pulling (MRM, 2011c)

MRM has continued to control Parkinsonia through the basal bark spraying technique. Individuals were sprayed along both diversions and within the mine site. Substantial effort has also been concentrated at the Bing Bong dredge spoil ponds where large infestations were identified in 2010 (MRM, 2011c). The method is proving effective with only one individual observed by the Independent Monitor along the McArthur River diversion and several identified at Bing Bong in an area which in previous years was densely covered with this species.

An area within the mine levee wall was treated for Annual Mission Grass by hand-pulling (MRM, 2011c). The individuals removed were in seed at the time and the Independent Monitor recommends that in future weeds are removed while not in seed to prevent further spread.

Infestations of the noxious weed Hyptis, *Hyptis suaveolens,* were observed along the banks of the McArthur River diversion. This species does not appear to have been included in weed control during the 2011 period although it is included in the Weed Management Plan (MRM, 2011c) for the 2011/2012 period.

It would be advantageous for MRM to investigate the possibility of working with pastoral properties located upstream on the McArthur River on a combined weed control program. Weeds can be spread by being transported by water and deposited downstream, meaning MRM could eradicate all weeds present within the operational areas only to have them reappear the following year from infestations present upstream of the mine. A joint weed

management program would allow for all weed stocks to be treated simultaneously making the chance of infestations less likely. This approach would in the long term save MRM costs in weed control and rehabilitation and also improve community relations.

The Independent Monitor is satisfied that MRM has adequately detailed weed control within the operational areas in the annual Weed Management plan and weed registers (MRM, 2011c).

Figure 30 Weed management carried out in 2010/2011 by MRM. Map sourced from the Weed Management plan (MRM, 2011c).

Stock exclusion fencing

As required, MRM carried out monitoring and repair of the cattle exclusion fence in the dry season of 2011 (MRM, 2010). The fence is required to restrict cattle from moving into operational areas and in particular, areas of rehabilitation. Cattle can hinder rehabilitation through the grazing and trampling of vegetation and the disruption of substrate causing erosion. The fence also plays a role in stopping the spread of weeds by cattle.

Each wet season the perimeter fence is damaged by floods and must be repaired in the following dry season. In 2011, a part of the perimeter fence along the McArthur River was relocated to higher ground allowing for fewer repairs to be required (MRM 2011a). Repair and relocation of the perimeter fence was contracted to All Fencing Services NT.

MRM should consider relocating the remainder of the fencing from flood prone areas to further decrease the need for works to be carried out annually. The Independent Monitor also recommends MRM investigate using plain wire in flood prone areas as barbed wire catches more debris during periods of flooding with resultant damage to fencing.

In October 2011, mustering of cattle within the mine boundary was performed by Laurabada Helicopters Pty Ltd. However, stock were observed along the diversion channel, near the Water Storage Dam and airport during the Independent Monitor's 2012 site inspection (Plate 18) as a result of fence destruction by 2011/12 wet season flooding.

Old Cattle exclusion fencing runs along the mine side of the McArthur River diversion. This fencing has been damaged by flooding and was observed during the May 2012 Independent Monitor site inspection lying on the ground with some lengths of barbed wire partially buried in the sand (Plate 17). The barbed wire presents a potential hazard to wildlife such as macropods as well as to staff managing weeds and revegetation, and should be removed.

Plate 17 Old cattle exclusion fence along McArthur river diversion which may be a hazard to fauna and staff.

Plate 18 Cattle observed near Water Storage Dam during the IM 2012 site inspection.

Tailings Storage Facility (TSF) seepage and rehabilitation of Cell 1

Direct seeding of grass species Black Speargrass (*Heteropogon contortus*) and Spider grass (*Brachyachne convergens*) of TSF cell 1 was carried out in February 2011 by MRM with the help of sub-contractors from the Seven Emus property (MRM, 2011d) (Plate 19). A second area at the far end of TSF cell 1 was seeded with native grasses at the end of 2011.

During the 2012 site inspection, natural reseeding was observed across TSF cell 1 and although sparse contained a range of shrubs up to 1.5m in height (Plate 20). Direct and natural reseeding appears to have had a significant positive effect on dust control at cell 1 with little dust observed around the TSF area in comparison with previous years.

Previously the rehabilitation plan for TSF cell 1 was to cover TSF with a clay cap, then overburden followed by topsoil and reseeding. During the May 2012 site visit, MRM informed the Independent Monitor team that temporary rehabilitation only will now occur consisting of only a clay cap and reseeding as the tailings in TSF Cell 1 may in the future be reprocessed. The disturbance of the tailings may result in short term increased seepage from the area into the creek.

Salt deposition was again observed at Surprise Creek as a result of seepage from the TSF and does not appear to have decreased substantially (Plate 21). Despite this, a frog and macrophytes were observed during the May Independent Monitor inspection within the seepage recovery sump (Plate 22), which is a a possible indicator of improved water quality of the seepage.

The Independent Monitor recommends that bi-annual vegetation surveys are conducted at Surprise Creek to monitor effect of tailings seepage on vegetation. Ideally, surveys should be timed to monitor wet season and dry season leachate impacts on vegetation separately (for example early dry season for wet season and late dry season for dry season).

The Independent Monitor suggests that MRM put increased efforts into monitoring the possible negative effects on flora aquatic fauna (fauna discussed in the following sections).

Plate 19 Area of TSF cell 1 hand-seeded in 2011 by MRM and sub-contractors from Seven Emus property as observed at site inspection in May 2012.

Plate 20 Sparse natural revegetation of areas of TSF cell 1 with no topsoil observed during 2012 site inspection. This area allows run-off to flow around the edge of the TSF to a collection point for pumping to TSF cell 2. Clay top soil piles will be dispersed to control area of erosion on the surface of TSF cell 1.

Plate 21 Salt accumulation from tailings seepage at Surprise Creek observed during May 2012. The water quality of seepage appeared to improved since the previous year, perhaps due to reduced water levels in the TSF or from fresher water travelling subsurface from the WMD.

Plate 22 Seepage recovery pond at Surprise Creek where a frog and macrophytes were observed within the pond.

Plate 23 Bustard observed on TSF Cell 1 clay cap.

Plate 24 Freshwater Crocodile (*C. johnstonii)* in WSD during May 2012 site inspection.

Water Management Dam

Good vegetation growth was observed surrounding the Water Management Dam (WMD) adjacent to TSF Cell2. Water quality in the dam appeared to be good with the area observed to be supporting a range of wildlife including abundant small fish, many species of waterbirds (Little Black Cormorant (*Phalacrocorax sulcirostris*), Pied Cormorant (*Phalacrocorax varius*), Pied Heron (*Ardea picata*), Great Egret (*Ardea alba*) Australian Snakebirds (*Anhinga novaehollandiae*), Brolga (*Grus rubicunda*) and Pelican (*Pelecanus conspicillatus*) and a Freshwater Crocodile (*Crocodylus.johnstonii*) (Plate 24).

Rehabilitation and monitoring of other areas around the mine

Ongoing rehabilitation is being carried out at McArthur River and Barney Creek diversions, TSF Cell 1 (discussed above) and Bing Bong Port (discussed in Section 3.) Additional areas have also begun to be rehabilitated within the mine operational areas. In 2011 these included:

- Tubestock planting was carried out in late 2011 behind the Pacrim ROM pad. Approximately 1500 individuals were planted consisting of River Red Gum and *Melaleuca sp.* This area was not visited by the Flora/Fauna section of the Independent Monitor team during the 2012 site visit; and
- an area of 1.5 hectares within the pit wall was cleared, re-seeding with native grasses and irrigated using Pit water (Trial irrigation for grasses document).

As part of lasts years Independent Monitor report it was recommended that MRM include a status update in the MMP on the major areas to be rehabilitated, indicating whether they are still operational, the areas that have been completed and when rehabilitation is likely to commence. While MRM did include a table in the 2011/2012 MMP (section 3.3, MRM 2011a) detailing areas where rehabilitation has begun or has been postponed but does not outline area which will be rehabilitated in the future.

In the previous Independent Monitor report (for the 2010 Operational Period), the Independent Monitor expressed concern that previous MMPs (MRM 2009 pg 113, MRM 2010 pg 148) stated that native and exotic grasses would be sown. Although the 2011/2012 MMP (MRM, 2011a) does not state that exotic species will be used it also fails to state that only native species will be used. This should be rectified in future MMPs.

Topsoil management

In the 2011/2012 MMP, MRM has included a topsoil management section. This section provides more information than seen in previous MMPs including information on where topsoil will be sourced from (section 4.1.7.7), where the topsoil will be stockpiled and where it is destined for (section 4.1.1.1), as per Independent Monitor recommendation (EES, 2011). Figure 4.1. in the 2011/2012 MMP illustrates the locations of topsoil stockpiling (Figure 31). Map should be improved as it is difficult to determine were topsoil stockpiles are located.

Recommendations mine site flora monitoring

- More focus on planting of targeted species Freshwater Mangrove *Barringtonia acutangula* and Native Cane Grass *Chionachne cyathopoda* along the river diversions;
- increase planting on bank slopes of river diversions;
- expand vegetation monitoring on the McArthur River diversion to include additional sites to allow representation of the entire length of the channel;

- incorporate additional analogue sites into the survey design for vegetation monitoring at Barney Creek. The current analogue site located on Surprise Creek is unsuitable due to its location on a different system and its position downstream of the tailings dam;
- increase weed control on the opposite bank of the McArthur River diversion;
- conduct trials on the survival of different riparian species at different levels on the bank slopes to allow selective planting;
- conduct monitoring on heavy metals in vegetation in McArthur River and Barney Creek to investigate uptake of metals as a result of mine operation;
- Investigate the possibility of conducting a combined weed control program with pastoral properties on the McArthur River, upstream of the mine. This will help to stop the re-infestation of weed controlled areas from infestations further upstream (outside of operational areas) and will promote community relations;
- consider relocating the remainder of the cattle exclusion fencing along McArthur River diversion to higher ground to decrease chances of it being breached during the wet season;
- replace barbed wire in fencing with plain wire as barbed wire catches debris in high flood periods, weighing the fence down and causing it to become dislodged;
- remove old cattle exclusion fencing along McArthur River diversion as it poses a hazard to fauna and staff;
- conduct bi-annual vegetation monitoring at Surprise Creek to evaluate effects of tailings leachate;
- if TSF cell 1 is relocated in the future, intensive monitoring of the flora and fauna of Surprise Creek should be conducted before, during and after works due to likelihood of short term increased seepage during disturbance of cell;
- expand information regarding rehabilitation in Table 3.1 in 2011/2012 MMP to include areas which will require rehabilitation in the future; and
- improve topsoil map to make it clearer where topsoil is stockpiled.

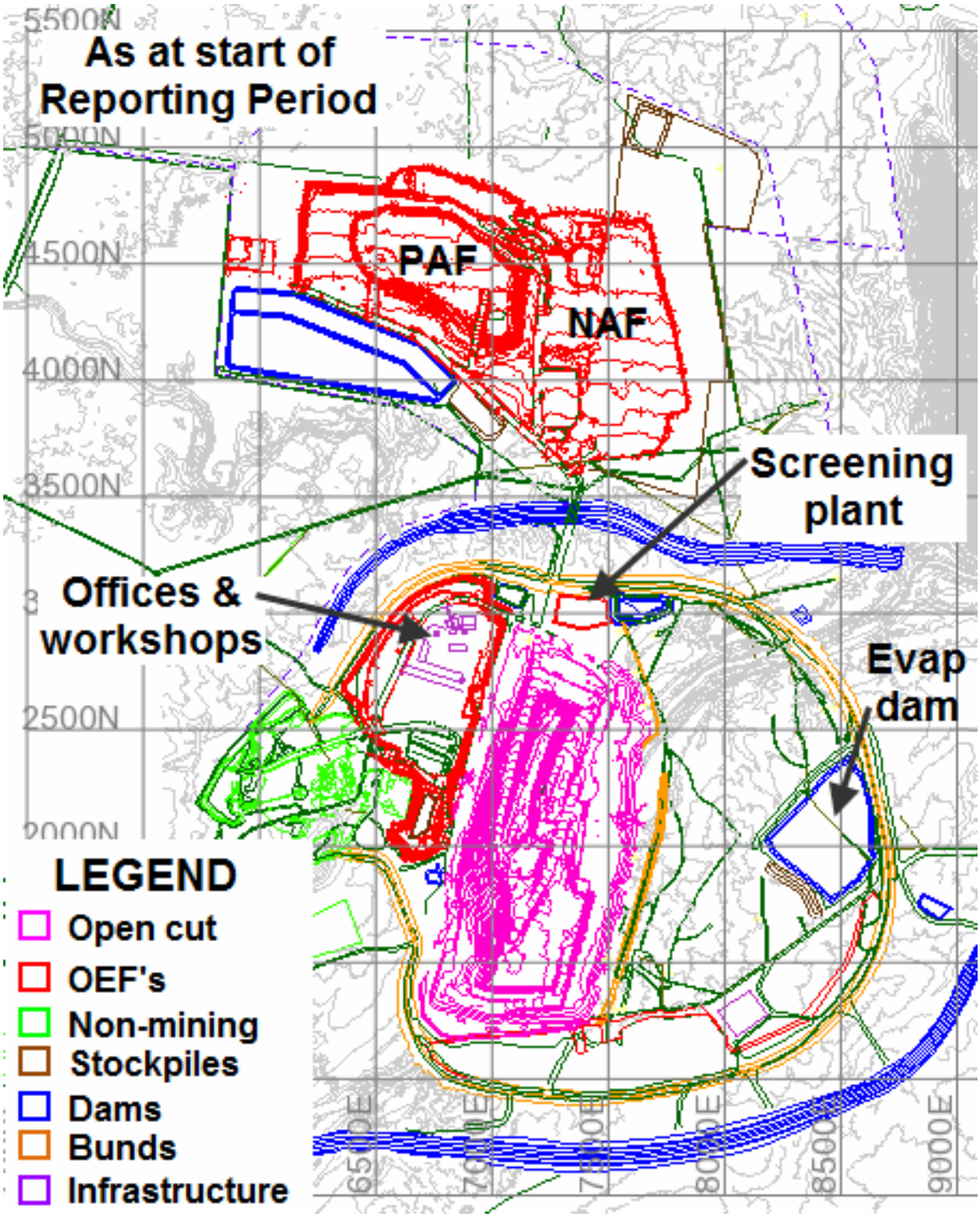


Figure 31 Map showing location of topsoil stockpiling at the McArthur River mine. Topsoil is labelled as stockpiles and is represented by brown lines . (Figure sourced from 2011/2012 MMP)

9.7.4 Review of Mine site fauna monitoring

As a condition of commonwealth approval for the expansion of the mine, MRM are required to conduct specific monitoring of the threatened species Freshwater Sawfish, Purple-crowned Fairy-wren and the White-browed Robin. MRM also carry out macro-invertebrate surveying to assess the health of the McArthur River and Barney Creek diversions.

Riparian Bird monitoring

Riparian Bird monitoring and banding program was conducted in May/June 2011 and September 2011 by Ecological Management Services (EMS) (2011c, 2012b). Riparian bird monitoring is carried out bi-annually to aid in the assessment of the health and progress of the rehabilitation areas along the banks of the McArthur and Barney Creek diversions.

162 two hectare plots were surveyed for 20 minutes each with all birds observed or heard within the plot recorded. Plots are located in both undisturbed areas of the watercourses and within the diversion. Particular attention is paid to indicator species, Purple-crowned Fairy-wren (PCFW) and the Buff-sided Robin (also known as the White-browed Robin). Intensive banding of these indicator species was carried out in 2007 with additional individuals banding each year where available (EMS, 2011c). These two species are suitable indicator species as they both use riparian habitats almost exclusively and are highly territorial. The Independent Monitor is satisfied that the riparian bird monitoring is carried out thoroughly, data is interpreted sufficiently and suitable recommendations are provided.

Some areas of Barney creek are now supporting higher numbers of birds since vegetation and particularly, Cane Grass has become established. McArthur River still exhibits large areas of bare or sparse patches resulting in significantly fewer birds compared to reference sites.

The Purple Crowned Fairy Wren has not yet been sited at the McArthur River diversion but due to increasing healthy stands of Native Cane Grass the Purple Crowned Fairy Wren was observed during the May/June survey entering the rehabilitation area on the upper bank of the Barney Creek diversion for the first time.

Cattle have a significant effect on riparian vegetation through grazing and trampling. This has been shown to greatly affect bird abundance and composition found in an area with increased numbers of birds including Purple Crowned Fairy Wren observed near the southern bund and at the diversion inlet inside the cattle exclusion fence area. The opposite was seen in areas were fencing had been damaged by flooding (EMS, 2011c). The White-browed Robin has been recorded a number of times during survey in the undisturbed riparian forests on the lower bank of McArthur River particularly within areas of Freshwater Mangrove. (EMS, 2011c)

Banding of indicator species has been conducted since 2007 with re-sightings of banded birds decreasing significantly since 2007 (EMS, 2011c). A total of 34 Buff-sided Robins have been banded since 2007 with six re-sightings in May/June and 7 re-sightings in September. 220 PCFWs have been banded so far with 23 re-sightings in May/June and 74 re-sightings in September (EMS 2011c, EMS 2012b).

As results indicate that both the presence of Cane Grass and the structure of cattle exclusion fences play a substantial role in the number of bird species found in an area, the Independent Monitor advises that MRM continue to concentrate efforts of established Cane Grass stands, ensuring fencing is complete and stock are mustered out of the exclusion areas as soon as practical.

While MRM followed the Independent Monitor's recommendation to plant more Cane Grass along the McArthur River diversion for the Purple Crowned Fairy Wren, only a small number were planted. Increasing planting of this species will be beneficial to habitat development for the targeted bird species.

Fish monitoring

Annual fish monitoring in the McArthur River was carried out in May/June 2011 and October by Indo-pacific Environmental (IPE). A total of 47 sites were sampled along the McArthur River and tributaries using fyke, seine and gill nets, and electrofishing equipment. The aim of the survey was to:

- monitor fish assemblage in permanent and semi-permanent pools;
- monitor populations of vulnerable species, the Freshwater Sawfish including collecting data on recaptures;
- investigate metals in biota;
- monitor fish passage through the diversion (through tagging of bony fish and Freshwater Sawfish);
- compare fish assemblages in the diversion to sites in the McArthur river;
- compare size and distribution of Cherabin *Macrobrachium rosenbergii* from within the diversion to those in undisturbed areas of the river as a potential indicator of habitat complexity;
- assess success of Large woody debris addition to diversion; and
- collate data on reptiles in the McArthur River diversion.

An additional survey was conducted in September 2011 in Surprise and Little Barney Creeks in response to concerns over elevated sulphate levels as a result of tailings dam seepage (Indo-pacific Environmental, 2011b).

The vulnerable species, Freshwater Sawfish, Pristis microdon, protected under Federal and Territory legislation was captured four times during the May/June survey, upstream of the mine (eight mile waterhole) and downstream of the mine (before and after the Burketown crossing) A fifth individual was observed free-swimming within the McArthur River diversion (Indo-pacific Environmental, 2011a). During October, one individual was captured above the Burketown crossing (Indo-pacific Environmental 2012)

The fish monitoring reports for the 2011 Operational Period state that the monitoring of heavy metals in biota is included in the survey design (Indo-pacific Environmental, 2011a, Indo-pacific Environmental 2012). Samples for analysis were only collected during the May/June survey and not in October. Despite samples being collected there is no results or discussion of heavy metal or lead isotope analysis provided. Metal analysis of biota is important in assessing the health of the waterbodies and should be conducted bi-annually in future with results and discussion included in the reports. The Independent Monitor also recommends that metal and lead isotope analysis in molluscs is added in future surveys if possible, as they are good indicators of metal contamination.

Despite recording elevated levels of sulphate and conductivity, fish abundances in the Surprise and Little Barney Creeks were found to be high. The Independent Monitor agrees with the recommendation proposed by IPE to investigate further the effect of sulphates on the fish communities in Surprise and Little Barney Creeks. This should include the addition of bi-annual fish surveys in Surprise and Little Barney Creeks to the current survey design, further analysis of the depositional salt and investigation into the potential of negative effects

of elevated sulphates on the aquatic community and revision of current water quality guidelines if necessary (Indo-pacific Environmental, 2011b).

In the last quarter of 2010, an additional three piles of large woody debris (35 placed previously) were placed in the upstream section of the McArthur River diversion (MRM, 2011f). On inspection in November 2011, many piles from both the 2010 and 2011 placements were observed to have remained in situ or travelled a short distance downstream. A greater diversity of fish were captured at sites where large woody debris had been placed previously than sites without (Indo-pacific Environmental, 2011b) indicating the importance of the large woody debris in creating a natural river environment.

The Independent Monitor is satisfied that MRM have continued to monitor and add large woody debris into the diversions where available as recommended in the Independent Monitor report last year.

The tagging program of Freshwater Sawfish and bony fishes is continuing to add important data on fish with a total of 1100 fish tagged as of October 2011 by MRM staff and 7 recaptures (Indo-pacific Environmental 2011, MRM fish tagging register).

No annual fish monitoring occurs on Barney Creek. One site on Barney Creek was sampled in 2011 as part of the Surprise and little Barney creek survey in response to concerns over salt deposits (Indo-pacific Environmental, 2011b). Annual fish survey of the Barney Creek diversion along with reference sites on undisturbed areas of the creek should be carried out in order to evaluate the health of the creek through the Barney Creek diversion.

As requested by NRETAS, MRM contracted Hydrobiology to conduct an ecotoxicity evaluation of McArthur River Mine levee water in April 2011 (Hydrobiology, 2011). This was required to obtain a Waste Discharge License allowing MRM to discharge excess water pooling around the mine levee wall to be pumped into the diversion channel. A number of plant and animal species were used in the toxicity tests and included one fish species *Lates calcarifer* (Barramundi) larvae. Results found that in order for the discharged water to not have a negative effect on the receiving aquatic environment, the flow of water in the diversion must be high enough to allow the levee water to be diluted 25:1.

While the Independent Monitor is satisfied that the results of the ecotoxicology evaluation were discussed sufficiently it does agree with Hydrobiology's recommendation to, in furtue, use a full suite of tropical native species as part of the test design, in order to create a more robust data set as only 1 algae, 1 macrophyte, 1 water flea, 1 fish and 1 shrimp were used in the testing (Hydrobiology, 2011).

MRM also contracted Metserve to evaluate the effect on sulphate leachate from TSF cell one on fish and macro-invertebrate species in the Surprise and Barney Creeks through the review of the current water monitoring program, existing knowledge and literature review of existing scientific papers (Metserve, 2011). The Independent Monitor is satisfied that all information was thoroughly reviewed by Metserve, results were evaluated sufficiently and recommendations provided would be beneficial if added to the survey design.

Macro-invertebrate monitoring

MRM have continued macro-invertebrate monitoring (EMS, 2011b) as per Independent Monitor's recommendations (EES, 2011). Macro-invertebrates were sampled at riffle and edge habitats at 21 sites using standard AusRivAS sampling procedures (methods from Lamche, 2007). At each site a range of data including analysis of surface water, fluvial sediment, spatial and habitat variables were measured during sampling (EES, 2011).The

Independent Monitor is satisfied that the survey technique is thorough, results are sufficiently discussed and recommendations are provided.

Due to the lack of riparian vegetation the macro-invertebrate assemblage in the McArthur River diversion continues to be impaired and because of the rocky nature of the banks, macro-invertebrate communities found in edge sites more closely resemble that which would be found more commonly in riffles (EES, 2011).

Despite possible seepage from the TSF and increased sulphate levels in the Surprise/Barney system, macro-invertebrates were found to be at most, slightly affected by seepage. Possible reasons include buffering by dolomite rock and particularly high wet season flows in 2011. Macro-invertebrates would likely be affected more negatively in years with lower flows therefore yearly data should be continued to collate seasonal data trends (EMS, 2011b).

Continuing to add and maintain large woody debris and/or rocks in the diversions will allow riffles to be formed thus creating a more natural habitat for macro-invertebrates.

Recommendations for Mine site fauna monitoring

- Increase density of the important riparian plant species; Native Cane Grass, Freshwater Mangrove and Pandanus along the river diversions;
- ensure cattle are excluded from restoration areas along the diversions;
- continue to monitor and add large woody debris annually;
- include molluscs in metal analysis of biota in river diversions, if possible, as they are good indicators of metal contamination;
- make fish monitoring in Surprise Creek and Little Barney Creek an annual event to investigate further the effect of sulphates and metals on fish from tailings seepage;
- conduct fish monitoring on Barney Creek within the diversion and on undisturbed stretches to evaluate the effect of the diversion on fish assemblages; and
- conduct ecotoxicology evaluation that includes a suite of tropical native species as part of test design in order to create a more robust dataset (Hydrobiology, 2011).

9.7.5 Review of Bing Bong Port flora monitoring

Monitoring at Bing Bong and dredge spoil rehabilitation trials

MRM is yet to find a PhD student to undertake trials for dredge spoil rehabilitation and monitoring of the vegetation outside of the dredge spoil has not occurred. Alternative options must now be looked at such as hiring a contractor to conduct trials and surveys, as this poses a substantial gap in monitoring at Bing Bong Port.

Rehabilitation of dredge spoil ponds

Direct seeding of the dredge spoil ponds occurred during the first half of 2012 (Figure 32). An area of 13.61 hectares was seeded using *Astrebla squarrosa, Brachyachne convergens, Eulalia aurea Heteropogon contortus* and *Xerochloa imberbis* (MRM Rehabilitation Jan-June 2011 document).

Increased cover of vegetation of the dredge spoil was observed during the site inspection although cover in places, particularly in low areas, was still quite sparse. Elevated mounds in the spoil ponds have been very successful in allowing grasses to establish and reduce wind erosion and dust. Areas outside of the ponds close to the spoon drain were very low in

coverage with large areas of salt deposition on sulphate soils observed hosting mostly patches of salt tolerant *Samphire spp*. and *Trianthema sp.* (Plate 27).

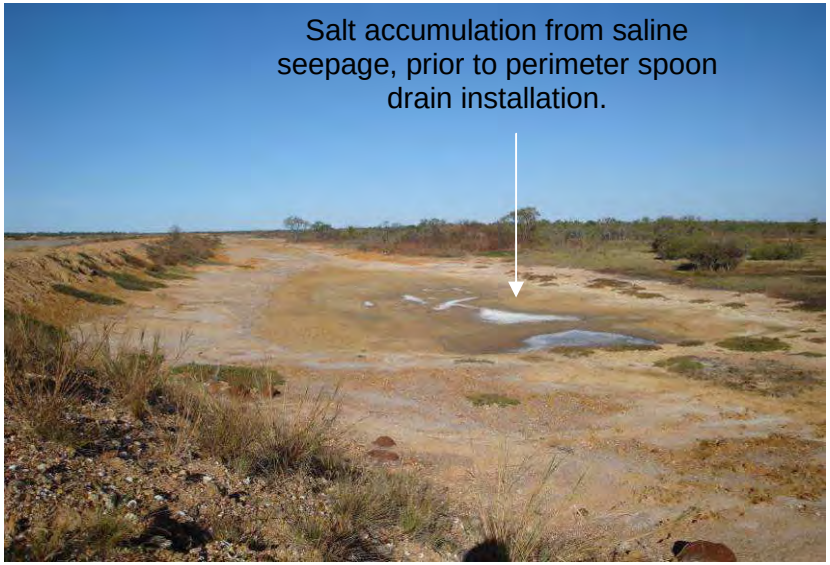
Vegetation dieback is still occurring outside of the dredge spoil spoon drain, although improvements can be seen since the addition of the spoon drain (Plate 27). Monitoring of the vegetation in these areas would provide valuable information on the health of the vegetation and steer rehabilitation and control efforts.

The drain at the dredge ponds was excavated in November 2011 to repair areas of damage due to erosion and cattle crossing. Damage was observed during the May 2012 site inspection mainly from repeated cattle crossing. It is recommended that the drain is again excavated prior to the onset of the wet season in 2012 and repeated annually.

Weed control at Bing Bong appears to have been particularly successful (Figure 33), with only several Parkinsonia individuals observed at the dredge ponds in 2012 (see Weed Management, Section 9.7.3).

Figure 32 Direct seeding conducted at Bing Bong dredge spoil ponds between January 2011 and June 2011. Map sourced from MRM Rehabilitation Jan-June 2011 document.

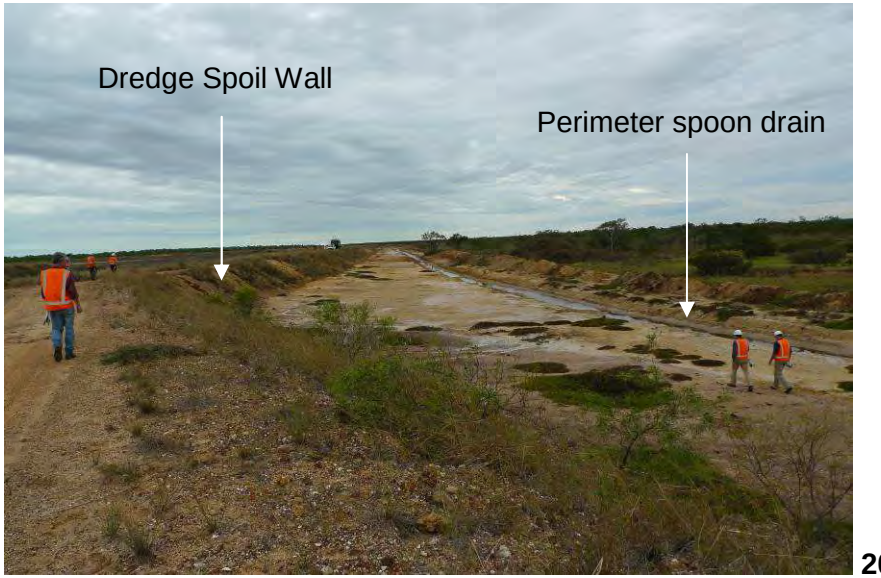
Figure 33 Weed management conducted at Bing Bong during 2010/2011 period. Map sourced from Weed Management Plan 2011-2012 (MRM, 2011c).



2009

2010

2011



2012

Plate 25 Photographic comparisons showing the outer toe of the Bing Bong dredge spoil ponds and spoon drain, which was installed in late 2009 to divert saline leachate seeping from the spoil ponds away from the surrounding vegetation and out to sea.

2009

2010

2011

2012

Plate 26 Series of annual photographs showing an area of vegetation die back (due to saline seepage) outside of the Bing Bong Dredge Spoil Ponds. The outer spoon drain installed in mid 2009 appears to have been effective in redirecting saline seepage, and regeneration of the affected area is slowly progressing.

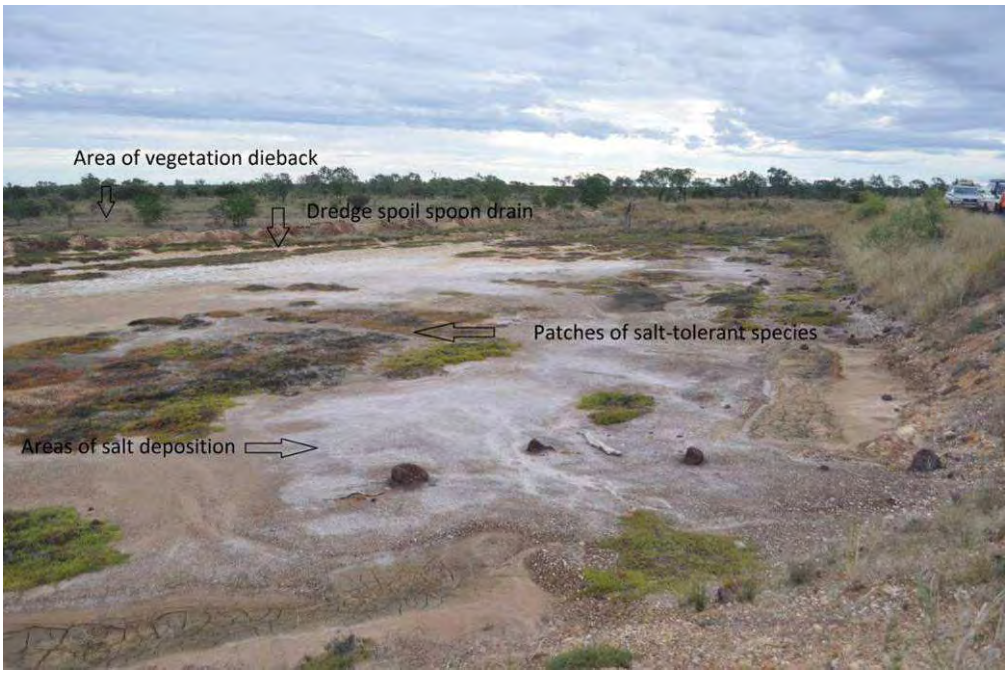


Plate 27 Photograph taken during May 2012 site inspection showing salt deposition and salt-tolerant species between dredge spoil ponds and spoon drain and area of vegetation dieback in the background. Photograph: Independent Monitor.

Bing Bong flora monitoring recommendations

- Investigate alternative options for dredge spoil rehabilitation trial as a monitoring gap has now existed for a number of years;
- conduct monitoring of vegetation surrounding the dredge spoil spoon drain experiencing vegetation dieback;
- spoon drain maintenance works should be carried out annually to remedy damage caused by erosion and cattle;
- exclude cattle from dredge spoil area; and
- continue with weed control program in place.

9.7.6 Review of Bing Bong Port fauna monitoring

Mosquito monitoring (Mine and Bing Bong Port)

As per commitments outline in the 2010/2011 MMP, MRM have continued to conduct routine mosquito monitoring.

Sampling was conducted monthly during the dry season (May-October) and fortnightly in the wet season (November-April) at four sites around MRM and two sites at Bing Bong. Trapping was conducted by MRM staff with collections then sent to the Medical Entomology Department, Darwin (Department of Health, 2011). Members from the Department of Entomology (DOE) also made a mine site visit in March 2011 and a visit to Bing Bong in July 2011 as recommended by the Independent Monitor with the aim of identifying possible container breeding and ground pool sites (Department of Health, 2011).

High pest problems of a number of species were observed at both Bing Bong and the mine site during the wet season. The DOE found numerous artificial receptacles, particularly tyres, at the mine site which were acting as breeding sites for mosquitos (Department of Health, 2011).

Many potential ground pool sites were also identified at both the mine including grassy depressions at the airport, sewerage plant overflow drain, depressions along the banks of the McArthur River diversion (likely made during construction) and flooded area between ROM and Barney Creek (Department of Health, 2011). Efforts should be made to rectify these depressions through construction of drains or filling the depressions.

At Bing Bong port, artificial receptacles observed by the DOE team included old tyres and pot plant drip trays (Department of Health, 2011). During the Independent Monitor site inspection tyres were observed piled next to the barge loading facility. All tyres had large holes cut into them, sufficiently allowing water to drain (Plate 28)MRM informed the Independent Monitor team that the purpose of the holes was that they could be chained together at a later date and not for mosquito control although they are useful for this purpose also (G. Taylor, pers. comm, 2012).

The Independent Monitor has previously recommended that drainage holes be inserted into waste tyres to prevent pooling of water within. MRM replied to this recommendation with the comment “Tyres will be removed as per the Waste Tyre and Conveyor Belt procedure (MRM, 2011h) on an annual basis”. The current procedure does not include inserting drainage holes and the Independent Monitor recommends that this is included in the procedure in future.

Suitable ground pool sites at Bing Bong port were observed in the form of depressions and alongside the access tracks within the dredge ponds. Pooling was also observed by the Independent Monitor during the site inspection, in particular, in isolated patches along the diversion drain mostly caused by disruption of the drain by cattle crossing.

Currently MRM does not carry out mosquito larval surveys at the mine site or Bing Bong port. The Independent Monitor agrees with the recommendation included in the Department of Health report (2011) which advises MRM to at least survey for mosquito larvae in artificial ponding areas three days after a large wet season rain.

Plate 28 Tyres observed at Bing Bong port in May 2012. Most with holes bored into them. Photograph: Independent monitor.

Migratory Bird Surveys

In accordance with Commonwealth conditions applied as part of the expansion of the mine (2011/2012 MMP, section 5.2.13.), MRM commissioned Environmental Management Services to survey the Migratory shorebirds in the Port McArthur area in 2011 (EMS 2011a, EMS, 2011b).

Surveys were conducted in January 2011 and April 2011 to coincide with summer and Northern staging periods, respectively. The study area extending from Rosie Creek to Robinson River incorporated 180km of coastline. The coast is divided into 18 sections which are surveyed by flying a slow transect in a helicopter in each section. Species and abundances were recorded for each site including recording of any banded individuals. Ground-truthing was also conducted at some sites when needed. The Independent Monitor is satisfied that the survey design is sufficient, results are interpreted and recommendations on future monitoring are supplied.

The 2011 Operational Period surveys have again shown the McArthur Port area to be an important bird area particularly for the Asian Dowitcher (*Limnodromus semipalmatus*). The migratory bird report states “The Asian Dowitcher count for January 2011 is exceptional, suggesting that the site supports a high percentage of the Australian population or that the Australian population estimate may need to be revised” (EMS, 2011a pg. 22).

In 2012, an additional area from Rosie Creek to the mouth of the Limmen Bight River was surveyed to assess bird numbers in the area (EMS, 2012), and found it to be a significant area for the Great Knot (*Calidris tenuirostris*) and Black-tailed Godwit (*Limosa limosa)*. The Independent Monitor believes that this further enhances the dataset and should be repeated in future surveys.

Bing Bong Fauna recommendations

- Include monitoring of mosquito larvae in artificial ponding areas, three days after large wet season rains in the annual mosquito monitoring program (Department of Health, 2011);
- incorporate the insertion of drainage holes in Waste tyres into the Waste Tyres and Conveyor Belt Procedure;
- rectify ground depressions by inserting drains and/or infilling, where possible;
- if not already in place, an insecticide spraying register should be kept to assess areas and times of year that spraying is conducted; and
- extend survey area to the Limmen Bight River in bi-annually migratory bird surveys as it appears to be a significant area for migratory species.

9.7.7 Review of marine biota monitoring

Seagrass monitoring

Seagrass monitoring was carried out in November 2011 by BMT WBM (2012). The survey focus area is located within the mining lease boundary (MLN1126) encompassing the swing basin and the boat navigation channel. A submersible video camera is lowered into the water and down to the seabed at sites within the focus area where it feeds video footage back up to the boat. A Van Veen Grab is also utilised in order to take a sample of the seagrass assemblage below to verify identifications. Species composition and relative density was recorded (BMT WBM, 2012). The Independent Monitor is satisfied that the data collected is

interpreted and recommendations are given although the Independent Monitor does feel that the survey design, particularly the area covered and comparison to control sites; could be improved and synergistic cooperation with external studies would be useful.

Survey results found that seagrass coverage is continuing to increase although changes in distribution and densities are occurring for which the reasons are not understood.

In 2011, The Independent Monitor recommended that control sites should be incorporated into the current survey design as they are essential in order to determine if a change in the assemblage of seagrasses is due to MRM actions or a more widespread issue or natural occurrence. This was also included as a recommendation in the 2010 and 2011 Operational Period seagrass survey reports (BMT WBM 2012, BMT WBM 2011) MRM response to this recommendation was "This will be looked at as per the Annual Seagrass Survey comments and proposed in the 2012 survey". Further information could also be obtained from surveys previously conducted at the nearby National Park, Marine Park and Indigenous Protected area.

Barranyi National Park is located on the North Island in the Sir Edward Pellew Island group (Parks and Wildlife Commission of the Northern Territory, 2012a). Plans of Management have been drawn for the park since 1998 and data gathered during the life of the park would contribute valuable control data which could be used throughout the MRM marine monitoring program

The Limmen Bight Marine Park is located west of Bing Bong port and consists of 880Km2 of diverse marine habitats and extensive seagrass meadows from which control data could be obtained. A marine preserve has also been proposed which extends further out to sea and closer to Bing Bong port (Parks and Wildlife Commission of the Northern Territory, 2012b).

Yanyuwa Indigenous Protected Area (IPA) declared in July 2011 runs alongside the McArthur River extending out into the Gulf of Carpentaria and encompassing the Sir Edward Pellew Islands (Department of Sustainability, Environment, Water, Populations and Communities, 2012). Data collected within this IPA could be utilised as additional control data to evaluate the Seagrass communities within the mining lease at Bing Bong.

Heavy metal monitoring in biota

Metal concentrations in two species of oysters (*Saccostrea cucullata and Saccostrea mordax*) from the Bing Bong and Sir Edward Pellew Islands sites were within the range of concentrations measured in the previous annual monitoring programs. A comparison of metal levels between species showed that *S. mordax* had higher concentrations of Cu and Zn than *S. cucullata* across all sites with the highest concentrations in *S. mordax* from Sir Edward Pellew Island sites. The Cd and Pb concentrations in oysters from all sites were below the ANZ Food Standards (2009) Maximum Levels for molluscs (Streten-Joyce and Parry 2012).

The gastropods, *Telescopium telescopium* and *Terebralia semistriata*, collected from among the mangroves on the beach immediately west of the loadout facility had elevated Pb and Zn concentrations and high Pb isotope ratios. These results show that the Pb and Zn derived from MRM ore concentrate is being assimilated by *T. telescopium* and *T. semistriata*. The Cd and Pb concentrations in *T. telescopium* and *T. semistriata* were below the ANZ Food Standards (2009) Maximum Levels for molluscs (Streten-Joyce and Parry 2012).

There was no measureable impact on seawater, surface sediments, oysters or seagrass along the Bing Bong coast, Sir Edward Pellew Islands and the eastern beach area adjacent to the swing basin (Streten-Joyce and Parry 2012).

The seagrass species, *Halodule pinifolia and Halophila ovalis*, from three sites along the Bing Bong coast, had metal and Arsenic (AS) concentrations and Pb isotope ratios, in leaves and roots, within the ranges that have been reported since 2002 for these species (Streten-Joyce and Parry 2012).

The Independent Monitor is satisfied with the methods used for heavy metal monitoring in biota and the interpretation of the data. No recommendations were given in the report. The Independent Monitor suggests that for clarity of the report the oysters are categorised as bivalves while *Telescopium telescopium* and *Terebralia semistriata* are categorised as gastropods and not molluscs as oysters are also molluscs.

Local concerns

During the May 2012 visit, the Independent Monitor talked to a number of local residents in the township of Borroloola to identify any concerns which they may have. Concerns included:

- low numbers of mudskippers along the coast;
- the effect of the mine on dugongs and sea turtles;
- die back of Mangroves to the west of Bing Bong; and
- the effect of the Aburri taking shelter behind the Sir Edward Pellew Islands during bad weather.

In 2012, the Sea Rangers conducted a survey of mangrove health along the coast and concluded any damage present was not due to the effects of the mine but most likely due to storm damage. A Traditional Owner also informed the MRM that he had a witnessed an increase in dugongs in the McArthur port area in recent times (G. Taylor, pers. comm, 2012). It has also been reported by traditional owners that turtle fat is again a green colour rather that the black colour that was reportedly observed in stressed turtles around 2005.

Marine monitoring recommendations

- Establish control sites for seagrass monitoring;
- use data from the Yanyuwa IPA, Barranyi National Park and Limmen Bight Marine Park as control data in Marine monitoring program particularly in the sea grass monitoring;
- in the annual marine report, categorise oysters as bivalves and *Telescopium telescopium* and *Terebralia semistriata* as gastropods as both as molluscs and this can cause confusion; and
- continue to observe trends regarding the presence of heavy metal in sediments on the beach west of the loadout facility.

9.7.8 Overview of the past five years of flora and fauna monitoring

MRM have shown a high level of procedural compliance over the previous five years with rehabilitation and monitoring moving in a positive direction. For the most part, MRM have considered recommendations submitted by the Independent Monitor and implemented them in a timely manner. Positive actions and improvements carried out over the past five years of particular note include:

- continued rehabilitation of McArthur River and Barney Creek diversions with increased vegetation observed on both, in particular on Barney Creek;
- a riparian habitat along Barney Creek diversion that has seen the recent reuse of the area by the Indicator species, Purple-crowned Fairy-wren;
- addition of large woody debris to the diversion to establish a more natural habitat for aquatic fauna;
- monitoring of the vulnerable species, Freshwater Sawfish and other fish in the McArthur River system with results showing that Freshwater Sawfish are continuing to utilise the river despite the addition of the diversion;
- monitoring of fish in Surprise and Little Barney Creeks in 2011 in response to concerns of negative effects on aquatic fauna from tailings seepage;
- conducting bi-annual riparian and migratory bird surveys;
- annual seagrass surveys conducted at Bing Bong Port since 2004;
- annual investigation into the metals contained in seawater, marine sediments and biota;
- taking local concerns into consideration including implementing a Macropod survey at Bing Bong in 2010. Survey showed MRM were not negatively affecting Macropod populations;
- continued monitoring of macro-invertebrates;
- addition of rehabilitation vegetation monitoring on Barney Creek in 2008 and on McArthur River in 2010;
- successful propagation on riparian vegetation in the MRM plant nursery;
- noticeably reduced dust emissions from the TSF as a result of clay capping and direct seeding;
- installation of a recovery bore at Surprise Creek to recover tailings seepage;
- spoon drain construction around the perimeter of the dredge spoil at Bing Bong to direct saline leachate away from surrounding vegetation and out to sea;
- weed management program at Bing Bong port and MRM resulting in a significant reduction in Devils Claw, Parkinsonia and Bellyache Bush; and
- relocation of cattle exclusion fence to higher ground in 2011 resulting in less damage to the fence.

While significant developments have been made at MRM, there are areas which still require improvement. Important areas still requiring attention are further restoration of the McArthur River diversion, improved survey design in vegetation monitoring along the diversions and seagrass surveys at Bing Bong and implementation of annual fish monitoring of Barney, Surprise and Little Barney Creeks. A full list of recommendations is provided below.

9.8 Review of Geotechnical Monitoring

9.8.1 Tailings storage facility and Water Management Dam

Documents reviewed

The following documents were reviewed by The Independent Monitor prior to the inspection of the site:

- Tailings Storage Facility Monthly Operating Reports (MRM, 2010-2011);
- Tailings Storage Facility Monthly Operating Reports (MRM, 06/2011- 12/2011);
- Tailings Storage Facility Infrastructure Inspection Reports (MRM 2010-2011);
- Sustainable Development Mining Management Plan (MRM October 2010);
- McArthur River Mine – Tailings Storage Facility (URS, March 2010);
- McArthur River Mine – Stage 1 Design Report for Proposed Raising of Cell 1 of the Tailings Dam (Maunsell McIntyre, 2000);
- McArthur River Mine – Tailings Storage Embankment Inspection Report (Australian Mining Engineering Consultants, January 2003);
- Geotechnical Report on Tailings Dam Raises - McArthur River Mine (Australian Mining Engineering Consultants, June 2003);
- McArthur River Mine – Tailings Storage Facility Dam Safety Review Report (Allan Watson associates, 2010);
- McArthur River Mine – Hydrochemical Investigation of the Tailings Storage Facility (Golder Associates, June 2011);
- McArthur River Mine, OPSIM Water Management Update and Review (Water Solutions Pty Ltd February 2011); and
- Allan Watson Associates, Memo, McArthur River Mine – Tailings Storage Facility Development Cell 2 Stage 2.

Update on recommendations from 2011 Audit

The following points provide an update on the recommendations made within the Independent Monitors Audit in 2011.

TABLE 14 UPDATE FROM 2011 AUDIT

Previous audit comment	Update on action from MRM
The tailings storage facility should not be used to store excess water:	Although slightly improved when compared to the observations made during the 2011 Audit, there are still significant volumes of water stored in Cell 2 and against the embankment. It is pertinent that all efforts are made to increase tailings deposition along the (southern) embankment walls and move the stored water away from the embankment (refer Plate 32).
The use of large fans to increase evaporation:	During the 2011 Audit the application of large fans to Cell 2 aiming at increasing the evaporation was discussed. Verbal communications with Sam Strohmayr confirmed that this was trailed during the 2011/2012 wet season but was found to be ineffective and the fans were subsequently returned to use in the pit area.
Analysis of the emergency spillway required:	The temporary raise of the spillway was removed and no longer present as observed during the 2012 Audit
Routine monitoring of phreatic surface within the embankments is required:	A limited number of bores and piezometers have been installed however they are insufficient in number and geographic spread to allow quantification of the phreatic surface throughout the facility.
Freeboard in Cell 2 is inadequate, excess water to be removed or facility raised:	Also referring to the 2010 Dame Safety Audit, the required storage is still estimated to be insufficient. It is understood that a raise is currently being designed. Additional free board should be created before the onset of the 2012/2013 wet season. Verbal communications with Sam Strohmayr confirmed a 4m raise of the embankment wall is scheduled to be constructed before the 2012/2013 wet season. The raise includes lifting of the concrete spillway.
Improve the monitoring regime within the facility, in terms of details and scope (include review of water levels, piezometric data and survey monuments) so that the level of surveillance is in line with the ANCOLD guidelines for high hazard category dams.	MRM should commit to transitioning the monitoring program from a qualitative based assessment to a quantitative one, although planned this has not yet been implemented or observed during the 2012 Audit. Some improvement has been made such as the installation of survey monuments and limited piezometers but insufficient to allow quantitative assessment. The current level of monitoring is well below the standard which is required to allow comprehensive assessment of the performance of a high hazard dam and as such presents a risk that the facility is being operated in a manner which is unsafe or may lead to undesirable impacts or failure of the facility.
Determine the safe operating limits for the piezometric levels within the embankment and settlement in the embankment crest:	There is no evidence that this has been conducted and as limited monitoring has been installed it would not be possible to verify that the piezometric levels are below the safe operating limits.

Comments on documentation reviewed

The comments below are based on this year's review and a continuation of the comments and notes of the previous audit. Where no change has been observed and the observation is still relevant, the 2011 Audit notes have been reproduced again this year:

- no Construction Reports or As Constructed Drawings were available for the Cell 1 of the TSF facility. This prevents a complete assessment of the facility being conducted as there is no documentation regarding the material used in construction or the as constructed configuration of the facility;
- the current embankment configuration and embankment crest levels do not match the design embankment levels and embankment configuration shown in the Geotechnical Report on Tailings Dam Raises - McArthur River Mine (Australian Mining Engineering Consultants, June 2003); it is therefore unclear if the current facility complies with the assumption made within the design report; and
- the Tailings Storage Facility Dam Safety Review Report (Allan Watson Associates, 2010) does not include an analysis of the embankment stability and therefore fails to address the safety of the current facility adequately. This is a high priority issue that needs to be addressed as soon as possible; however a full and meaningful stability review of the embankment cannot be completed until piezometers are installed within the embankment to determine the phreatic surface within the embankments. It is therefore recommended that the designer of the facility is contacted and a plan for installation of piezometer is produced and the installation expedited to allow a comprehensive stability review to be conducted.

Tailings Storage Facility embankment observations

The Independent Monitor inspected the TSF embankment batters, crest, toe, and downstream area of the embankments. The following observations were noted:

- the embankment appears in generally good condition and there are no signs or settlement or deformation of the embankment;
- the embankment crest appears in good condition with generally good trafficable surface, little or no signs of erosion or rat holing. The embankment crest has a slight slope towards the upstream side allowing for drainage into the facility. No significant changes or signs of stress were observed;
- salt precipitation indicates that the seepage at the toe of TSF Cell 1, along the north eastern margin adjacent to Surprise Creek, is still occurring. The Independent Monitor has previously posited that seepage is likely caused by a paleochannel underlying the TSF. MRM are considering further, and an ongoing electromagnetic (EM) survey programme is being conducted to investigate seepage further;
- with regard to the geo-polymer cut-off wall and recovery bores aimed at recovering tailings seepage, no further geotechnical observations are made this audit period. During the 2010 Independent Monitor Audit it was recommended that a quantitative assessment of the effectiveness of the geo-polymer cut-off and dewatering bores be conducted. As noted in the previous Independent Monitor Audit, a study on the groundwater chemistry and hydrology was conducted by Golder Associates but it failed to conclude with regard to the effectiveness of the geo-polymer cut off and dewatering bores. No further works have been yet undertaken to address this in more detail;

Plate 29 Seepage flowing from the toe of TSF Cell1 embankment towards Surprise Creek is captured within a sump, shown above.

A single line of piezometers and monitoring bores (6 monitoring locations) have been installed across the north eastern margin of Cell 1 adjacent to where seepage is expressing. To date, these bores have only been used to collect factual rather than interpretive data. These bores have not yet been used to assess their effectiveness when operating, nor have they been used for interpretation and modelling.

Settlement monitoring prisms have been installed on the embankment crests of both Cell 1 and Cell 2, which are scheduled to be monitored on a bi-annual basis.

During the 2011 Independent Monitor inspection, seepage was observed downstream of the water management dam (WMD) embankment at the intersection between the WMD and TSF Cell 2. During the 2012 inspection, the area was dry, however, salt precipitation was visible (see Plate 30) . It has not yet been ascertained whether the seepage was from the WMD or TSF Cell 2. Works, such as EM survey, should continue to further investigate this seepage.

Plate 30 Seepage causing salt precipitation in an area south of the TSF Cell2, downstream from the 'contaminated waste area' of the WMD.

Recommendations from TSF embankment inspection 2012

Based on the embankment inspection, the following recommendations are made:

- as per recommendations made within the previous Independent Monitor audit, additional monitoring bores should be installed around the perimeter of both Cell 1 and Cell 2 to ascertain the level of the phreatic surface within the embankments; this will be required before the comprehensive safety audit can be conducted. The monitoring bores along Surprise Creek should be monitored to include an interpretive assessment of the seepage to investigate the likely source;
- a number of piezometers have been installed during the monitoring period, however they are limited to a single line across the embankment of Cell 1 and do not provide sufficient monitoring locations to gain an adequate understanding of the hydrogeological conditions present within the embankment. It is recommended that at least 6 lines of piezometers be installed in each of the TSF Cells (Cell 1 and Cell 2) with vibrating wire piezometers installed within the foundation material and tailings within three boreholes in each line;
- the Independent Monitor recommends that MRM investigate the origin of seepage at locations south of WMD and towards surprise creek. Investigation should assess the presence and likely effect of a paleochannel on the seepage as well as the source (WMD, Cell 1, or Cell 2?), of the seepage, and seepage flow direction;

- the phreatic surface in the area adjacent to Surprise Creek is currently high, as observed during the 2010 and 2011 visits, as evident by the seepage occurring at the embankment toe, and is likely to rise during the wet season when pumping is currently not conducted. By pumping year round it should be possible to lower the phreatic surface within the embankment toe at all times thereby increasing the overall geotechnical stability of the embankment and reducing the risk of piping failures through the embankment. As such, additional seepage control measures are recommended for seepage from Cell 1 into Surprise Creek, which include lowering the phreatic surface in the TSF to reduce seepage escaping to the environment. Furthermore, the system should be designed to allow seepage recovery to occur year round and consideration of a subsurface seepage recovery system with submersible pumps should be made; and
- as per the Independent Monitor's previous audit recommendations, a seepage recovery system is recommended downstream of the water management dam (WMD) embankment at the intersection between the WMD and Cell 2 to recover seepage in this area. To allow for subsurface collection during the wet season, the seepage system should be design to allow subsurface collection of seepage year round.

Tailings Storage Facility Cell 1 observations

The surface of Cell 1 had been completely covered with a layer of compacted soil cap at the time of the inspection in May 2012. Based on a visual inspection of the soil material it appeared to be lateritic clayey sand with gravel (see Plate 31). The capping should lead to some reduction in infiltration of rainfall into the tailings in Cell 1, however the primary purpose of the capping layer is to eliminate tailings dust being blown from Cell 1.

The surface of Cell 1 was sloped down to the perimeter embankment and directed to a sump at the south east and north west limits of the facility adjacent to the divide wall with Cell 2. The sumps had been used to pump water to the WMD during the wet season but no pumping was active at the time of inspection. The south eastern sump was equipped with a spillway, across the berm road, to allow excess water to discharge to Cell 2 if pumping capacity was exceeded (see Plate 35).

No major concerns or issues were raised regarding the top surface of Cell 1. The 2011 Independent Monitor Audit Report suggested a more robust erosion control and sediment collection systems such as rock check dams, however, with continuous efforts being made with regard to planting vegetation and reshaping of the cap, the actual erosion could be monitored and remedial action considered only if the vegetation and reshaping proves insufficient.

Plate 31 Salt Precipitation on clay capping of Cell 1, May 2012.

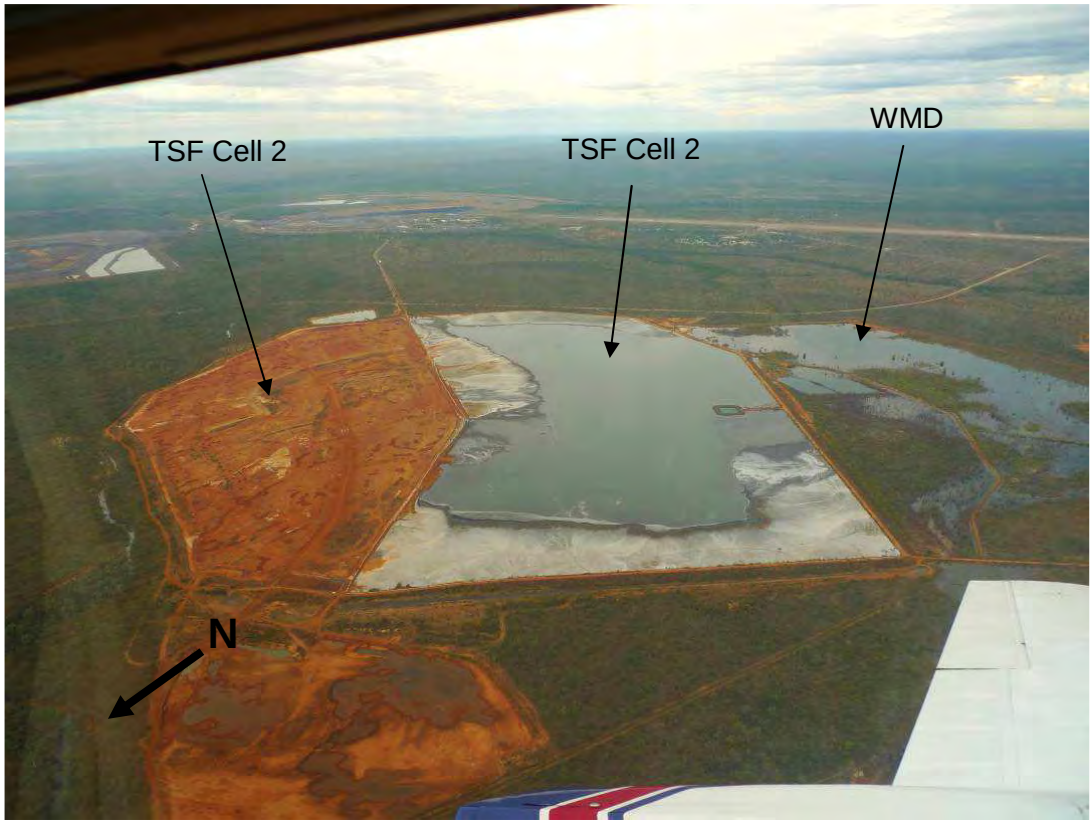


Plate 32 Aerial View of the Tailings Storage Facility, showing Cell1 (covered with a clay layer) to the left, and active Cell 2 to the right. May 2012.

Tailings Storage Facility Cell 2 observations

During the May 2012 site inspection, Cell 2 was being used for active tailings deposition. Deposition is via spigot deposition with Current deposition was concentrating on the southern wall of the facility with the aim to move water away from the embankment wall towards the centre of the Cell (see Plate 33). In spite of this current effort, the volume of water and the surface are of water is still exceedingly large (see Plate 32) and concerns with regard to storage capacity for tailings, storage capacity for storm water and stability related issues remain very much relevant and current.

Plate 33 Tailings deposition along southern embankment of Cell 2.

The west and east wall of the facility had tailings deposited up to November 2011. Reasonable drying and desiccation of the tailings beach is being achieved, as evident by deep desiccation cracking on the tailings beach (see Plate 35). The tailings along the western wall (six month since deposition) appeared still wet.

The Independent Monitor observed that *In-situ* geotechnical testing within Cell 2 (using cone penetration test (CPT) methods) has been undertaken in May 2012 (see Plate 34).

Plate 34 Recently (6 months) deposited tailings along eastern wall, which had recently been disturbed because of geotechnical testing (CPT).

Plate 35 Sump at south eastern limit of the facility between Cell 1 and Cell 2

Within the 2010, 2011 and 2012 Independent Monitor audits, the Independent Monitor has expressed significant concern with a large supernatant pond formed within TSF Cell 2, (see Plate 32), which touches the southern TSF Cell 2 embankment for much of its length. The length of the embankment wall exposed to the pond has been reduced in 2012, and tailings was being deposited along the southern wall (see Plate 33) at the time of inspection. The following comment from the 2011 Audit report still stands this period:

> *"The presence of the large pond will increase the phreatic surface within both the tailings beach deposits and potentially within the embankment and foundation materials which can lead to a reduction in the stability of the facility. Furthermore the large pond and high phreatic surface will apply a greater driving head which may result in increased seepage from the facility, either through the base of the facility or through the embankments*".

With regard to water storage and management associated with TSF Cell 2, the following observations for 2012 are noted:

- the water level within Cell 2 was at approximately 47.6m RL with the crest at RL49, providing an estimated 1.3m freeboard to crest and 400mm to spillway, with the spillway level at RL48;
- no issues with the concrete spillway were noted during the 2011 and 2012 Audits. The crest of the spillway is at 48m RL (Note: in 2010, the spillway had active seepage, however repairs to the spillway were carried out prior to the 2011 Audit and were noted Audit to have eliminated this seepage);
- the temporary bund constructed in the concrete spillway, noted in the 2011 Audit, was removed;
- the collector drains, along the east and west downstream toe of Cell 2 were observed to be holding water during the 2011 Audit. During the 2012 Audit no flow was observed within the drains. The sump at south eastern corner and little Barney Creek had some standing water (see Plate 36);
- during the 2010 visit a large pond of water was present to the northern west corner of Cell 2 , which is fresh water that has backed up from Little Barney Creek. At that time, the water body encroached on the embankment of Cell 2. During the 2011 Audit, the water body was still present although significantly reduced and wall away from the Cell 2 embankment toe. During the 2012 Audit, the water body appeared of similar size as during the 2010 Audit (Plate 37); and
- as an attempt to increase evaporation water was being pumped from the south eastern corner of the WMD to the north western corner of the WMD from where it was allowed to flow and percolate back towards the south eastern corner of the WMD.

Plate 36 Sump and drain along eastern embankment of Cell 2 near Little Barney Creek.

Plate 37 Ponded water from Little Barney Creek, which has pooled to the east of TSF Cell 2, and north of the WMD.

Recommendations from TSF Cell 2 observations

As noted in the previous Independent Monitor Audit, excess water should be removed from the Cell 2. We note that Last audit period, MRM had committed to utilising commissioning of evaporative fans to as a trial to increase evaporation from the facility to accelerate removal of water from the facility. Following the 2012 Audit, verbal communication confirmed that the fans were not effective at the TSF, largely due to the high winds in the area. As such, the fans have been returned to the pit area.

The volume of water stored on the facility is still higher than design assumptions indicated in the design documents reviewed. The comments made in the previous Audit remain valid:

> *"Storage of excess water on a tailings storage facility not specifically designed as a water retaining facility is considered to be a high risk operation which can lead to embankment instability. Available storage capacity is currently available within the water management dam (WMD) and consideration should be given to rapidly pumping the water off Cell 2 into the WMD where evaporation trails can be conducted without the risk of the storing excess water in Cell 2 for extended time periods".*

As commented in the previous Independent Monitor Audit report, a review of the design documentation indicates that the stability of the TSF Cell 2 embankment may be compromised by having water directly against the external southern wall. All stability assessments in the design reports show a tailings beach at the embankment, with the pond level adjacent to the embankment lower than was observed in the May 2012 site inspection. It is questionable if the upstream constructed embankments which do not have filters or seepage control features are designed as water retaining embankments and are capable of storing water directly against them without the stability and integrity of the embankments being compromised. To this end the following should be conducted as a high priority:

- installation of piezometers along the southern embankment to fully define the location of piezometric surface within the embankments;
- a full design and stability review of the southern embankment; and
- consideration should be given to relocating the decant pond to the common embankment between Cell 1 and Cell 2 where the increased phreatic surface will less likely effect the stability of the embankment as it is supported by the tailings stored within Cell 1. Furthermore this would allow any embankment raises along this common wall to be easily designed as water retaining embankments with appropriate design features (such as filter drains and drainage blankets) to be constructed.

We do note that tailings deposition is currently taking place along the southern embankment of Cell 2, which will eventually result in the water stored against the embankment wall being moved towards the centre of the Cell 2.

The Independent Monitor considers that drains along the northern perimeter of Cell 2 ponded water backed up from Little Barney Creek to the east of TSF Cell 2 will act to raise the phreatic surface at the toe of the TSF Cell 2, as surface runoff and rainfall cannot flow away from the facility and ponds rather than percolates into the ground. This could lead to reductions in the stability of the embankment. Consideration of replacement of the open drains with a subsurface drainage and collection system should be made. Furthermore the viability of eliminating the ponded water backed up from Little Barney Creek should be assessed.

The Independent Monitor recommends that a full review of the water balance model and storage capacity of the TSF is required prior to the 2012 wet season to ensure that sufficient capacity is available within the facility to store all tailings and waters over the coming wet season. To perform this work a clear understanding of the geometry of the tailings surface below the pond will be required which may require a bathymetric survey of the facility below the pond. An annual review of the water balance using the software OPSIM has been conducted which shows that the model at times underestimates the volume of water within the facility; better calibration of the model is required before it can be used to assess available storage within the facility.

Water Management Dam observations

The Water Management Dam (WMD) was inspected during the audit visit. The following observations were noted:

- the embankments of the WMD are generally in good condition with no visible sign of deformation of any erosional feature which would require remediation observed at the time of the inspection;
- both spillways observed were in good condition and showed no signs of erosion or distress; and
- regarding the two waste disposal sites located within the WMD, the contaminated waste area had been upgraded by raising the embankments to separate this area from the rest of the WMD.

Based on the inspection visit no major geotechnical concerns or issues were raised regarding the WMD.

Overview of the past five years of geotechnical monitoring of the TSF

The general trend with regard to the TSF has been positive. The closure of Cell 1, when considering capping, dust monitoring and vegetation has progressively improving. It is generally accepted that the grout curtain in ineffective at slowing or mitigating seepage migration from the TSF towards Surprise Creek. Further assessment may be required as to the actual source of the seepage, whether it stems from a high water table in Cell 1 or whether it stems from Cell 2 and the WMD where it is seeping downstream through a more permeable paleochannel.

MRM's geotechnical monitoring of the TSF has improved with the addition of piezometers however, further efforts are recommended. Periodic dam inspections should be carried out by a reviewer or review team that has not been involved in the design.

Monitoring and management of Cell 1 has improved over the past five years, and the first stage of capping of Cell 1 represents a positive step towards eventual closure. However, MRM have advised that tailings in Cell 1 may undergo reprocessing again before closure.

Improvements in the monitoring and management of Cell 2 have also been observed over the past five years. Initial Independent Monitor observations noted:

- seepage of the spillway apron;
- deep standing-water against the southern embankment;
- excess water stored in Cell 2;
- limited freeboard; and

- erosion of parts of the embankment.

Progressively, most of the issues have been addressed over the past five audits, most notably observed during the 2011 site inspection when tailings were being deposited against the eastern and part of the southern wall, with the aim of moving the ponded water away from the embankment walls. Further, the temporary spillway raise, observed during 2011, was removed this year. With regard to capacity restrictions, in-situ geotechnical testing was in progress during the 2012 site inspection, and a design for a proposed dam raise was underway.

Key outstanding issues, however, remain to be the lack of consistent independent review of dam inspections, the lack of proper stability analyses from independent reviews and a detailed review of the water balance. Furthermore, as long as the volume of water stored on Cell 2 remains significant and there is no clear picture of the water balance, the risk of overtopping during the wet season remains of serious concern. We note that the Independent Monitor's site inspection occurs after the wet season when water levels are high in the TSF. Throughout the dry season, water levels are reduced through evaporation and recycling efforts by MRM. Further MRM have advised (pers. comm. September 2012) that the upstream lift has commenced for Cell 2, which will increase the capacity of Cell 2. This lift will need to be reviewed as part of the next Independent Monitor audit.

9.8.2 Review of Overburden Emplacement Facility geotechnical monitoring

Documentation reviewed

- McArthur River Mine – Overburden Emplacement Facility (OEF) Design (URS, July 2008);
- Monthly Monitoring Reports (MRM 2010-2011);
- Weekly Monitoring Reports (MRM 2010-2011);
- Clay Sampling Testing Results (Various Laboratory Report 2010-2011);
- Memorandum Sharmil Markar, "Review of NEOF, 15th March 2012;
- MIN-TEC-PRO-1000-0026 Clay Liner Quality Control, 11 Jan 2012;
- MIN-TEC-PRO-1000-0025 NOEF As built Review and Sign Off Procedure I001 Rev0, 15 September 2011; and
- MIN-TEC-PRO-1000-0015 EOM NOEF Sampling Procedure I001 Rev 3, 01 June 2011.

Based on a review of the documentation above, the following points were noted:

- no recent in-situ compaction and moisture content test results could be located within the documentation supplied. Any areas of clay which are still exposed and have recorded low densities or low moisture contents should be reworked prior to placement of PAF waste;
- no test results with regard to liner specifications and QA/QC are reported on in the weekly or monthly reporting;
- only 17 laboratory tests have been reported on from October 2011 to December 2011, showing Plasticity Indicators and Particle Size Distribution (PSD);

- the monthly report discussion on the geotechnical quality control is limited without a complete set of results for the month being included to allow monthly review of the performance of the OEF; and
- the monthly (geotechnical) report does mention or include the OEF but only seems to focus on stability related issues and not on liner placement or liner quality control.Site inspection findings

The OEF was inspected as part of the Independent Monitor site inspection in May 2012. The inspection included viewing the OEF from a distance and an inspection of the top surface and tip head. The Independent Monitor's inspection resulted in the following findings:

- at the time of inspection no clay liner or NAF base was being placed or compacted at the OEF;
- no paddock dumping in advance of the end dumping of the PAF waste was observed at the time of inspection;
- the observation made in the 2011 Audit report regarding the large exposed basal clay liner was revisited. *"A large area of NAF base and clay base liner had been constructed extending several hundred meters in front of the active tip face. The clay was exposed to the elements at the time of inspection thus was likely to be desiccating".* Verbal communications with Karissa Grenfall, Mining manager, this year confirmed that the area of exposed basal liner was now reduced to "several metres" ahead of waste (Plate 38);
- verbal communications with Karissa Grenfall, Mining manager confirmed that no testing is carried out on quality and thickness of the basin liner;
- limited cover had been constructed on the top surface of the OEF (which could also be related to the next two observations regarding seepage);
- seepage was reported on the north eastern side of the OEF, however, initial assessment by MRM suggested the seepage to be run-off instead of seepage from the OEF; and
- further seepage was observed to be flowing from the toe of the OEF on the eastern side. The seepage allegedly reports into a small stream. The origin of the seepage has not yet been determined by MRM (see Plate 39).

Plate 38 Area of exposed clay liner has been reduced when compared to previous years, which is a positive improvement.

Plate 39 Area of seepage observed from the north eastern toe of the OEF. This seepage is collected in a downstream pump.

Recommendations for OEF geotechnical monitoring and management

Based on the inspection of OEF the following recommendations are made in relation to geotechnical aspects observed during the 2012 Audit:

- as stated in the 2011 Audit report "A layer of PAF waste should be immediately paddock dumped over the completed basal clay liner, as specified in the design report, to prevent desiccation of the basal clay liner". As confirmed through verbal communications with Karissa Grenfell, Mining Manager, the allowed exposed area of clay is now minimised;
- exposure of the completed clay cover on the batters to the elements should not be allowed, as this has the potential to desiccate the clay leading to cracking which increases the permeability of the clay. Furthermore the exposed clay on the batter is susceptible to erosion during rainfall events. A layer of NAF waste should be immediately dumped over the completed clay cover on the batter to protect the cover;
- although not directly a geotechnical issue, a cover should be constructed on the top surface of the OEF when it reaches design height and prior to each wet season to minimise infiltration of rainfall and runoff into the waste;
- implement and report on the QA/QC procedures for testing the clay liner as drafted and approved by MRM, and ensure the level of QA/QC in the MRM procedures is on par or better than the suggested URS procedures, so that the clay liner is being constructed in accordance with the design; and
- for all future cell constructions, ensure that the clay liner is placed under Level 1 supervision, or apply the specifications as drafted by MRM, if required in conjunction with URS.

9.8.3 Geotechnical review of river diversion channels

Documentation reviewed

The following document was reviewed by the Audit team prior to the inspection of the site:

- Construction Report – Levee & Diversions, McArthur River Mine Expansion Project, Xstrata Zinc (Connell Hatch 2009).

A review of the document indicates that the construction report is a high quality report containing sufficient details of the construction activities conducted for the channels to allow the channel to be fully inspected and assessed.

Update on Recommendations from previous Audit

The comment made with regard to erosion monitoring within the Independent Monitors Audit in 2010 and repeated in the 2011 Audit report notes that ongoing monitoring of the diversion channels is in place with MRM conducting regular visual inspections as part of rehabilitation works and photographic surveys conducted for both sides of the channel.

Site inspection findings

The Barney Creek Diversion and the McArthur River Diversion were inspected as part of the Audit visit. Based on the site inspection of the diversion channels no major geotechnical issues were noted. The extent of the erosion which was observed did not merit rehabilitation as the system should be dynamic with minor erosion and sediment deposition within the channels considered to be acceptable. Replacement of topsoil along the bund walls is probably not warranted as it is likely to be remobilised in subsequent flooding and a more resilient outer facing such as rock fill would be more appropriate. The Independent Monitor made the following observations of the diversion channels:

- the Barney Creek Diversion was generally in geotechnically good condition during the inspection;
- the banks of the McArthur River Diversion was generally in good geotechnical condition (see Plate 40);
- minor erosion of top soil from the pit bund was visible where surface water flows from the old river channel alignment into the diversion channel had occurred, this was also noted during the 2010 visit; and
- minor localised erosion was evident at various locations along the channel where loose uncemented soils were exposed in the diversion channel batter slopes.

Plate 40 McArthur River Diversion

Overview of the past five years of geotechnical monitoring of the river diversion channels

For both the McArthur River and Barney Creek diversion channels, the progress and evolution of their geotechnical stability has been similar. Initially revegetation appeared slow to establish and subsequently, embankment stability, erosion and rehabilitation did not progress as desired.

One issue of note, having been discussed previously, is the actual design of the McArthur River diversion. A long, fairly smooth (non-meandering) channel has not surprisingly caused issues in relation to vegetation and rehabilitation. Nevertheless, the work to date shows impressive improvement in the rehabilitation and stabilisation of both McArthur River and

Barney Creek. Remedial works such as placement of logs and creating areas where eddies will cause sand banks are working, albeit with trial and error. Geotechnical issues such as embankment stability are minimal and little risk of significant failure would exists regarding its current design.

9.8.4 Review of Bing Bong dredge spoil geotechnical monitoring

Documentation reviewed

The following documents were reviewed by the Audit team prior to the inspection of the site:

- Bing Bong Dredge Monthly Inspection Reports – (MRM 2011);
- File Note 8th April 2011 – MRM;
- photos of maintenance works carried out in 2011; and
- Allan Watson Associates, McArthur River Mine – Stability of existing dams data review.

Update on Recommendations from previous Audit

A review of the document indicates that geotechnical inspections throughout the 2011 Operational Period have been generally more consistent then observed in previous years. However, no design document for the dredge spoil ponds were included in the data package supplied to the Independent Monitor this audit, and therefore it surmised that no geotechnical design or construction specification was produced for the facility over this period.

Table 15 provides an update on the primary recommendations made within the Independent Monitors Audit of the 2010 Operational Period in 2011, regarding the geotechnical integrity of the Bing Bong Dredge spoils:

TABLE 15 UPDATE ON RECOMMENDATIONS FROM PREVIOUS AUDIT

Recommendation from previous audit	Update this audit
Establish a monitoring program for the Bing Bong dredge spoil ponds. This program should identify potential failure locations and establish a timetable for remediation works –	Over the 2011 Operational Period, no geotechnical monitoring such as piezometer within the spoil dump embankment or survey prisms were installed within the embankment and no monitoring was conducted in 2011.
The facility was dry at the time of inspection and appeared stable; however it is considered likely that during the wet season or during dredging activities when water is contained on the cells high seepage rates through the embankments are likely. This could increase the risk of an embankment failure. It is strongly recommended that a complete geotechnical review of the dredge spoil cell embankments is conducted prior to the upcoming wet season to assess the stability of the embankments. This would need to include borehole or test pits to ascertain the construction material used within the embankment and the foundation conditions at the site.	Following from the 2012 Audit, it was noted that, at the time of Audit, a CPT (Cone Penetration Test) investigation was ongoing and Test Pitting had been carried out. It is assumed that these works are in support of the recommended geotechnical review.
If further dredging is required, review the suitability of the containment structure	No dredging has been conducted since the previous audit however this recommendation is still valid should future dredging be required.

Site inspection findings

The Bing Bong Dredge Spoil Cells were inspected as part of the Audit visit. The Independent Monitor reviewed the geotechnical aspects of the spoil cells with other aspects such a rehabilitation success and geochemistry reviewed by other members of the Independent Monitors team. The Independent Monitor makes the following observations regarding the Bing Bong dredge spoil cells:

- the spoil cells were dry at the time of inspection with no water on the top surface of the cells. Deep desiccation cracking noted during previous Independent Monitor Audit was no longer visible on the top surface of the cells;
- significant areas of the cells appear to have been vegetated of at least contain vegetation when compared to the 2010 visit;
- in-situ testing, ongoing while Audit was taking place, confirms the previous thought of high clay content in the stored areas as well as in sections of the actual embankments;
- extensive erosion was evident on the outer batter of the spoil cell embankments, with the erosion pattern suggesting the material used in construction is highly dispersive;
- the material used to construct the embankment of the dredge spoil cells appears to be gravelly sand with low clay content. This material is unlikely to have a low permeability or have a low residual permeability;
- the lateral drain constructed around the dredge spoil cells was partially filled with eroded material from the spoil cell embankments with a very low flow capacity remaining;
- the area around the dredge spoil cells shows evidence that it is submerged during wet season and ponding of water was still present in places suggesting a high phreatic surface around the facility; and
- no engineered spillway structure was observed during the inspection visit.

Geotechnical recommendations for Bing Bong Dredge Spoil monitoring

Based on the inspection of Bing Bong dredge spoil, the following recommendations are made:

- no piezometric or crest settlement monitoring is conducted at Bing Bong, it is recommended that piezometers are installed around the facility and survey monuments are installed on the embankment crest, both the piezometer and survey monuments should be monitored on at least a quarterly basis and after heavy rainfall events;
- the existing drain around the facility needs to be cleaned out to allow free flow of water. It may also be beneficial to install a subsurface drainage system at a deeper depth to allow the phreatic surface at the embankment toe to be lowered further than can be achieved by the open drain; this should be assessed as part of the geotechnical review recommended in the previous comment;
- at present, stormwater is allowed to drain from cell to cell. However, an engineered spillway should be designed and constructed to allow excess water to be discharged from the facility in a safe manner in the event of heavy rainfall or excess water from dredging activities.

Overview of the past five years of geotechnical monitoring of the Bing Bong dredge spoils

The initial observations made at the Bing Bong dredge spoil resulted in a poor geotechnical rating of the spoil pond walls. Poor geotechnical monitoring was undertaken, and there was no record of actual design for the dredge spoil walls (embankments) or for water management.

Significant improvements at the dredge spoil ponds have been made recently. We note that *in-situ* geotechnial testing was being carried out during the 2012 audit. Embankments have been reshaped in damaged areas, vegetation is taking hold to stabilise the walls. Also, the surface water management has been addressed to some extent with drainage paths being created from cell to cell.

Overall, the general trend is positive with significant improvement having been made. However, outstanding issues remain such as the poor condition of some dredge spoil pond walls, with very deep erosion observed on the outer embankment slopes in 2012. Also, the storage capacity for further dredge material is questionable and should be assessed. Further, a water management design should be carried out allowing for a water balance model. Lastly, regular monitoring should be included as part of the operations at Bing Bong, particularly during the wet season.

Plate 41 Cone Penetrating Testing (CPT) geotechnical investigation being undertaken on the Bing Bong dredge spoil walls during the Independent Monitor's May 2012 site inspection.

9.8.5 Conclusions and summary of geotechnical recommendations

This audit period, the Independent Monitor identified areas of geotechnical monitoring that require modification. Some of the modifications require immediate attention, i.e. prior to the upcoming wet season, which are listed below. Other recommendations within this report can be completed as part of on-going site improvement and do not require immediate attention.

Tailings Storage Facility

- Still outstanding from the 2011 Audit, Installation of piezometers in embankments and comprehensive dam safety review including stability analysis of the embankments, especially the Southern Embankment of Cell 2 where water is ponding against the embankment;
- a review of available capacity to store tailings, process water and rainfall runoff whilst maintaining sufficient freeboard also taking into account the initiative to increase evaporation by using a larger part of the WMD. A review of the water balance including detailed water balance modelling should be carried out;
- following a water balance review, excess water to be removed from the facility;
- the pipeline on ramp to TSF should be bunded or secondary containment pipe installed; and
- as part of the proposed 4m raise, detailed stability analyses needs to be carried out, which includes monitored (as opposed to estimated) information regarding the phreatic surfaces in the tailings and embankments.

Overburden Emplacement Facility

- Technical specification for clay placement required and higher level of supervision for clay placement;
- application of the MRM standards and correlation of those standards to the original URS design requirements. Confirmation that the testing density and sample density is adequate and in line with best practice and standards;
- inclusion of liner testing in the geotechnical reporting; and
- construction of top cover over OEF prior to wet season.

Bing Bong Dredge Spoils

- Geotechnical review of embankment stability required prior to wet season (this is assumed to be taking place in the latter half of 2012);
- installation of piezometers and survey monument and a geotechnical monitoring program to be instigated;
- installation of engineered spillway required before wet season.

9.9 Review of geochemical monitoring

9.9.1 Review of OEF geochemical monitoring

The following documents and data files have been reviewed as part of the IMs review of geochemical monitoring at the OEF:

- MRM P/L *Sustainable Development Mining Management Plan (MMP) 2011/2012*, dated September 2011;
- MRM P/L *Sustainable Development Water Management Plan (WMP) 2011/2012*, dated August 2011;
- MRM P/L *Memorandum: Review of NOEF*, from Karissa Grenfell dated 15 March 2012;
- MRM P/L *EOM NOEF NAF Sampling, 29 May 2009 to 29 March 2012*. Spreadsheets and Laboratory Transcripts;
- MRM P/L *Independent Monitor's Audit Report of the McArthur River Mine for the 2010 Operational Period*, dated 16 November 2011;
- NT DME *Independent Monitor's Audit Report of the McArthur River Mine for the 2010 Operational Period*, Departmental Response to the Audit Report, November 2011;
- Metserve P/L *Overburden Emplacement Facility Management Plan*. MRM Phase 3 EIS Development Project, January 2012;
- Coffey Geotechnics P/L *Lysimeter Design Report for Overburden Emplacement Facility at McArthur River Mine*, dated 19 August 2011; and
- URS Australia P/L *Kinetic Leach Column Project Stage 7 – Project Review*, dated 28 November 2011.

Currently waste rock is being actively placed in the north overburden emplacement facility (NOEF). Potentially acid forming (PAF) waste is segregated and stored separately from the non acid forming/acid consuming (NAF/AC) waste, which is used as encapsulation material.

The waste rock characterisation at MRM is based on the initial geochemical assessment of diamond drill core samples from the 2002 feasibility drilling (35 holes for 1106 samples) and 2007 follow-up HQ coring (7 holes for 355 samples) that specifically targeted hanging-wall and footwall waste lithologies.

In the initial acid base assessment these samples were analysed for:

- total S%, sulfate, total C%, pH, ANC, NAG4.5 and NAG 7.0, to develop the acid base account (ABA); and
- metals: Pb, Zn, Cu, Fe, Ag, Al, Cd, Tl and Mn to identify the potential composition of any metal leachate that may be generated through weathering of the out of pit placement of the overburden or waste rock.

URS documented the geochemical characteristics of potential overburden generated from the proposed open-cut and developed the management strategies for overburden placement. Using samples from the 2002 drilling program, kinetic leach column studies were conducted by URS from 2002 to 2007. A total of 29 columns form the basis of the kinetic database for overburden and tailings geochemistry.

In November 2007, URS submitted the Stage 5 Project Review of the Kinetic Leach Column (KLC) Project with the following conclusions:

- hanging-wall lithologies:
  - upper pyritic shale: high metal and sulfate concentrations in leachate; brackish to saline EC; acidic pH; high total sulfur; moderate ANC; classed as PAF;
  - bituminous shale: some metal exceedance: Cd and sulfate; increasing EC; low pH; high total sulfur; moderate ANC classed as overall PAF; and
  - lower pyritic shale: some minor metal exceedance: Se and sulfate; slightly brackish EC; neutral pH; low to high total sulfur, high ANC; classed as NAF;
- footwall lithologies:
  - lower dolomitic shale: low metal and sulfate concentrations in leachate; low EC; neutral pH; elevated to high total sulfur; elevated to high ANC; classed as NAF; this unit appears to be footwall and immediately adjacent to the ore-body and has elevated sulfide sulfur concentration;
  - W-fold shale: low metal and sulfate concentrations in leachate; low EC; neutral pH; low total sulfur, minor elevated total S concentration; elevated ANC ; classed as NAF; and
  - Teena dolomite: low metal and sulfate concentrations in leachate; low EC; neutral pH; very low total sulfur; high ANC; classed as NAF.

The 2007 study has been followed up by the Stage 7 KLC study (URS, 2011), with the following conclusions:

- upper pyritic shale is confirmed as PAF and is predicted to generate acid and contain readily mobilised metals and salts;
- lower pyritic shale is confirmed as NAF from 125-130m and is predicted to generate slightly brackish, circum-neutral leachate with no elevated dissolved metals; however
- lower pyritic shale from 115-120m is potentially acid forming – low capacity (PAF-LC), and is considered a “moderate risk to downstream water quality”;
- bituminous shale is confirmed as PAF and is predicted to generate acid and contain readily mobilised metals and salts; and
- tailings slurry material and fired tailings material is PAF.

URS (2011) recommends conducting on-site kinetic leach testing.

The OEF design for managing PAF waste rock was developed by MRM/URS and comprises:

- construction of a NAF/AC base capped by a clay seal to form the foundation of the PAF cell;
- PAF waste is dumped within the PAF cell;
- NAF is loosely dumped to form outer walls of the PAF cell (5 m thick);
- the top of the PAF cell is a 0.6 m thick compacted clay layer;
- the flat surfaces of the cells and bases are sloped toward the PAF pond; and
- NAF/AC waste forms the 20 m thick rock armouring of the placed clay wall of the PAF cell.

The placement of clay is designed to reduce/limit/minimise infiltration of rainfall that can transport any weathering/oxidation products generated by the placed PAF material that is covered by the clay.

Some fundamental components of a successful design for containment for the PAF waste include the:

- NAF/AC waste must be correctly characterised and identified in-pit prior to placement on the OEF to ensure release of metals, sulfate and acidity from the placed OEF is minimal;
- PAF waste is covered prior to the wet season to limit water storage within the PAF cell;
- clay layer is armoured prior to wet season to minimise erosion and exposure of the underlying PAF material; and
- lower pyritic shale be considered as PAF or PAF equivalent as it will generate hazardous neutral drainage elevated in selenium.

The kinetic test work has found that the total sulfur content is variable, from negligible to 20% S. The review of the kinetic test work found that some of the material classed as NAF may be borderline PAF at best and may need to be reclassified as PAF. The data provided for monthly sampling of dumped material, as well as the agreed NAF/PAF classification, has been detailed in MRM MMP 2011/2012, Section 4.1.3, p.70. Figure 34 to Figure 36 below have been provided as a summary of this data (and criteria), which has been collected from May 2009 to March 2012. It is assumed there is unreacted hydrogen peroxide at the end of the test and no unreacted sulfides. This assumption needs to be confirmed in the high sulfur lithologies. These charts below have been presented to illustrate that a degree of PAF material, based on these laboratory tests, exists at the site and hence must be managed.

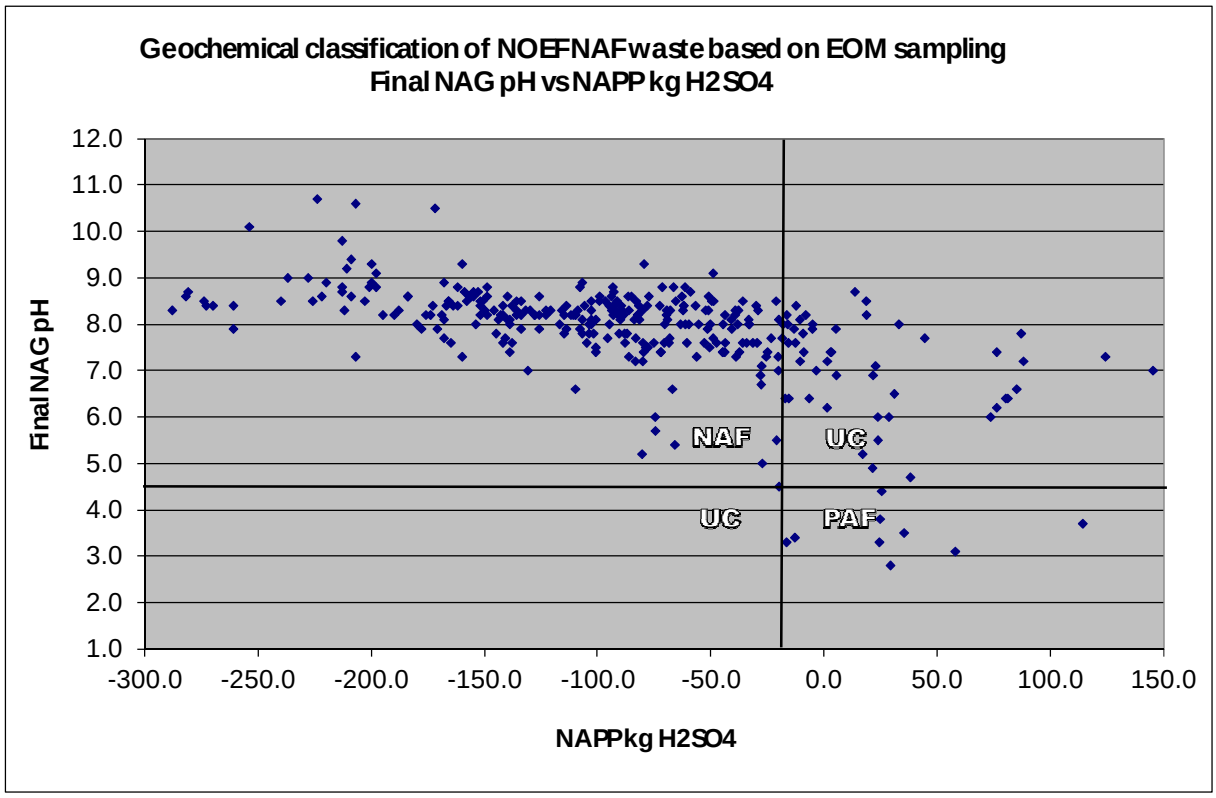


Figure 34 Geochemical classification using NAPP/ NAG pH

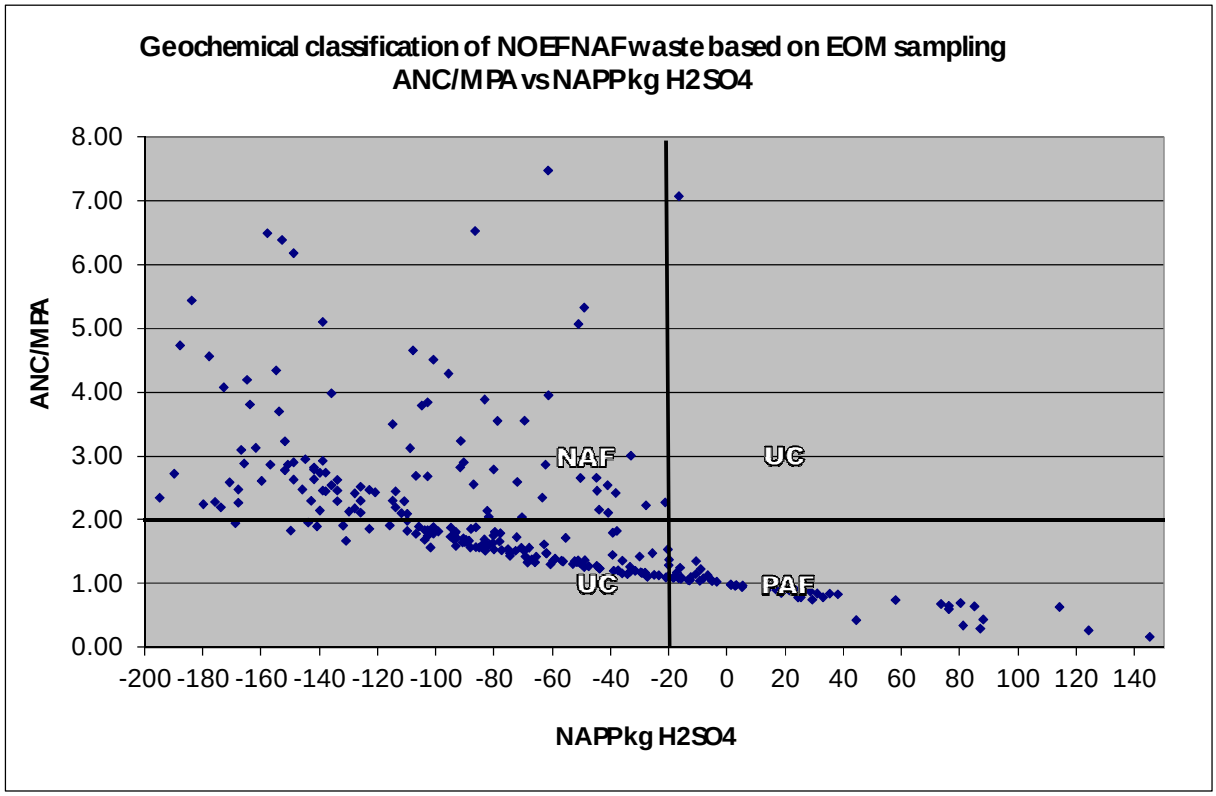


Figure 35 Geochemical classification using NAPP/ ANC/MPA

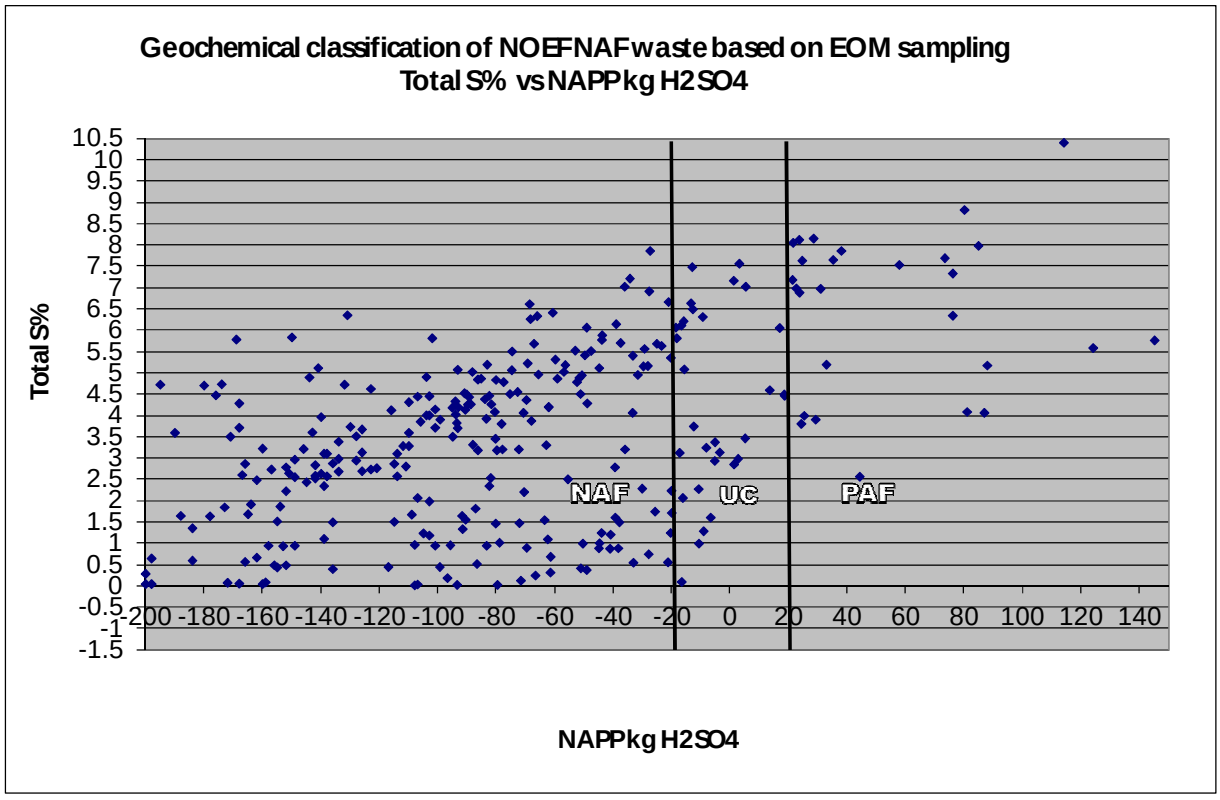


Figure 36 Geochemical classification using NAPP/ Total S%

The data presented in Figure 34 indicates that only about 10 of a total of 330 samples analysed is classified as PAF based on NAPP/ NAG pH, however a large number of samples (>40) are classed as UC (uncertain) due to elevated NAPP. This is also illustrated in Figure 36 , which shows that whilst all of the UC samples in Figure 34 have a NAG pH >4.5, total S is >2.5% (for >20 samples). Regardless of the NAPP classification (which is MPA – ANC), as the definition of PAF relates to the ratio of ANC and MPA the data presented in Figure 35 indicates that >10% of samples analysed are PAF (ANC/MPA <<2).

9.9.2 Recommendations for waste rock (OEF) management

A review of the classification of NAF waste is required as the sulfur content is very high—often >5% total S (see Figure 36 above). This material generates a neutral pH leachate, but with high sulfate and metals caused by an acid drainage reaction. Due to the low solubility of the carbonates, the acidity from metal sulfide oxidation precedes the dissolution of the neutralising carbonate. There is also the potential for bypassing of the neutralising mineralogy if a difference of particle size or abundance occurs in the heap between acid generating sulfides and neutralising carbonate.

There is also a need to review the mineralogy of the NAF, PAF and AC waste to determine what minerals are present, including carbonates, dolomites, sulfides and sulfates. It is noted that there are a lot of carbonate nodules present in the host rock sequence and the lead zinc deposits are known to contain siderite and manganese siderite. Both these carbonates are net neutral, therefore it is possible that the acid neutralisation capacity maybe overstated.

However, the acid neutralisation capacity is easy to check by undertaking a mineralogy investigation of the potential waste rock (NAF/AC) and using the correct ANC analysis to account for the presence of siderite. These recommendations have been previously detailed in Environmental Earth Sciences (2011).

The Independent Monitor has previously recommended the construction of larger kinetic cells or columns on site, to account for the fact that the laboratory based leach columns test only one range of particle size: <5-10 mm. As noted above, the surface area of the current column material is significantly higher than what is generated during mining and may not be a true reflection of the reactivity of the waste rock types under oxidising conditions.

Coffey (2011) undertook a lysimeter design report for the OEF, however misinterpreted the objective as being to collect leachate from the cover layer (Section 1, p1). The aim of the lysimeter program is to collect leachate that is percolating through the entire thickness of the OEF, for estimation of potential long-term acid production. It is also considered by the Independent Monitor that instrumentation for measuring water potentials could be considered further (for example, tensiometers or other soil moisture suction devices may prove more effective than vibrating wire piezometers as suggested in Coffey 2011).

It has also been recommended to review and analyse selected waste rock samples for sulfide sulfur (e.g. using the Chromium Reducible Sulfur or CRS method) as well as total sulfur. All hanging wall material should be considered to be PAF.

Due to the commencement of seepage from the NOEF along the northern and eastern edges of the facility (see MRM Memorandum dated 15 March 2012), the Independent Monitor recommends the consideration of placement of nested piezometers in these locations. If installed, these bores should be incorporated into the current water quality monitoring program (as per MRM WMP 2011/2012). In addition, Metserve (2012) recommends a monitoring program for the OEF soil, surface water, groundwater and sediment (Table 6-1, ppE2-42-43). For the groundwater and surface water paprameters, the Independent Monitor has the following recommendations/ suggestions:

- filtered metals and metalloids also include Al, Fe, Mn and Se;
- cations include NH_4-N;
- anions include HCO_3 (alkalinity), NO_3, NO_2, PO_4 and F, in addition to Cl and SO_4; and
- total metals can be removed from the groundwater suite.

9.9.3 Review of tailings geochemical monitoring

The following documents and data files have been reviewed as part of the IMs review of geochemical monitoring at the TSF:

- Golder Associates *Hydrogeochemical Investigation of the Tailings Storage Facility, McArthur River Mine prepared for MRM P/L*, report 107633048-003-Rev0, dated 17 June 2011;
- MRM P/L *Independent Monitor's Audit Report of the McArthur River Mine for the 2010 Operational Period*, dated 16 November 2011;
- NT DME *Independent Monitor's Audit Report of the McArthur River Mine for the 2010 Operational Period*, Departmental Response to the Audit Report, November 2011; and
- URS Australia P/L *Proposal – MRM New TSF Cell Seepage Modelling*, dated 20 January 2012.

As detailed in the previous Independent Monitor report, major geochemical (and hydrogeological/ hydro-geochemical) issue at the TSF is leakage of leachate (acid and saline, and containing dissolved metals) to Surprise Creek. MRM (2011, p6) states that a peer review of Golder (2011) has been engaged, however this document has not as yet been cited by the IM. The only new document made available for review relating to this issue appears to be a URS proposal for seepage modelling (URS, 2012). The Independent Monitor agrees with the proposed scope of the URS proposal, in particular the use of Particle Tracking modelling as part of the MODFLOW-SURFACT modelling.

Sections of the Independent Monitor 2011 review (Environmental Earth Sciences, 2011) that remain relevant have been reiterated below.

A thorough review of earlier documents has revealed the following conditions and characteristics that would most certainly change the tenor of the interpretation and conclusions of Golder (2011):

- tailings runoff water has been acid since as early as 2005 and elevated zinc breakthrough was evident in Surprise Creek as early as July 2006 (Appendix I, Soil Con Systems, June 2007);
- it was also noted that old creek beds pass under the tailings dam and these have a measured permeability of 86 m/day (Soil Con Systems, April 2007, p.12);
- the tailings dam at its closest is within 50 metres of Surprise Creek and the tailings are now 10.5 metres thick, with a surface approximately 15 metres above the creek;
- the gradient has been at its steepest for the last six years and has had a water level in the dam set at about one metre above the tailings surface. This is equivalent to a gradient of about 0.2; and
- other historical information records that a sulfate plume was detected in the creek within 18 months of the tailings dam commencing operations, when the tailings would have been less than two metres thick and the gradient about 0.1.

Golder (2011) uses a permeability of 1.73 m/day, a gradient of 0.04 and a zinc and lead breakthrough estimated to be 100 to 200 years from commencement. The actual gradient can be measured by the fall and distance from MW3 to Surprise Creek. This measurement should be used when the conceptual flow model is updated and observations used to check solute flow velocity equations, prior to updating or running any solute transport models.

Golder (2011) concludes the tailings will remain neutral for years to decades and in so doing imply that the tailings will eventually become acid. Using as input the current concentrations of lead, zinc and cadmium in the tailings porewater, Golder (2011) suggest it will be years to decades before lead and zinc concentrations in Surprise Creek may lead to adverse environmental impacts. However, modelling was not done on concentrations of these metals when the tailings become acid. Golder (2011) note that the objective of a closure strategy should be to reduce oxidation and maintain saturation of the tailings, however, this will be a very difficult objective to achieve.

The Independent Monitor agrees with the Golder (2011) recommend that mitigation strategies should be undertaken, including reprocessing the tailings and at the same time undertaking remedial works to create a liner to intercept the seepage.

It is currently unknown when the tailings mass will consume all the buffering capacity, however undertaking an acid/ base balance using only the XRD mineral data, provides an interesting clue. This data has been reproduced in Figure 37 below.

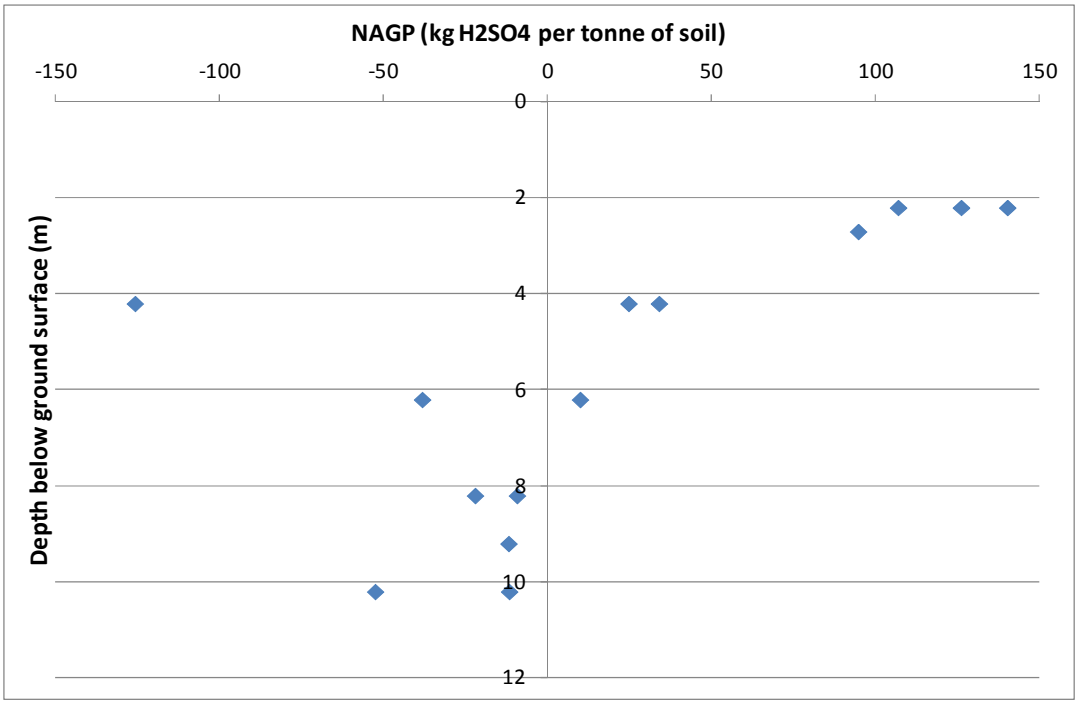


Figure 37 Net Acid Generation Potential calculated from mineral percentage developed from XRD Data provided in Golder (2011, Appendix F).

It is clear that when the tailings were first deposited they would not produce acid leachate (NAGP ≤-9 kg H_2SO_4/T). A change must have occurred in the top 3 metres of tailings, possibly in the composition of the ore, as the tailings deposited during this period have substantially more pyrite (and slightly less dolomite), and will potentially generate substantial acidity when the buffering capacity of the tailings has been depleted. The tailings data indicate two changes in milling, and though the original tailings will not generate acidic

leachate, the tailings deposited over the last five years will. However, both TSF Cells have been designed on the basis that acidic leachate will not occur.

Water levels in WMD are rising. In order to dispose of the water, MRM have increased the evaporation area by creating some internal berms within the higher topographical areas within the WMD walls on the south western and western side of the WMD. For this reason, water has been pumped up from the ponded water in WMD and discharged into the uncleared area of the high topographical area (see Plate 42). This water ponds behind the internal dams as shown in the aerial photograph (Plate 43)

Plate 42 Fresh water being discharged into uncleared area of the WMD to aid evaporation.

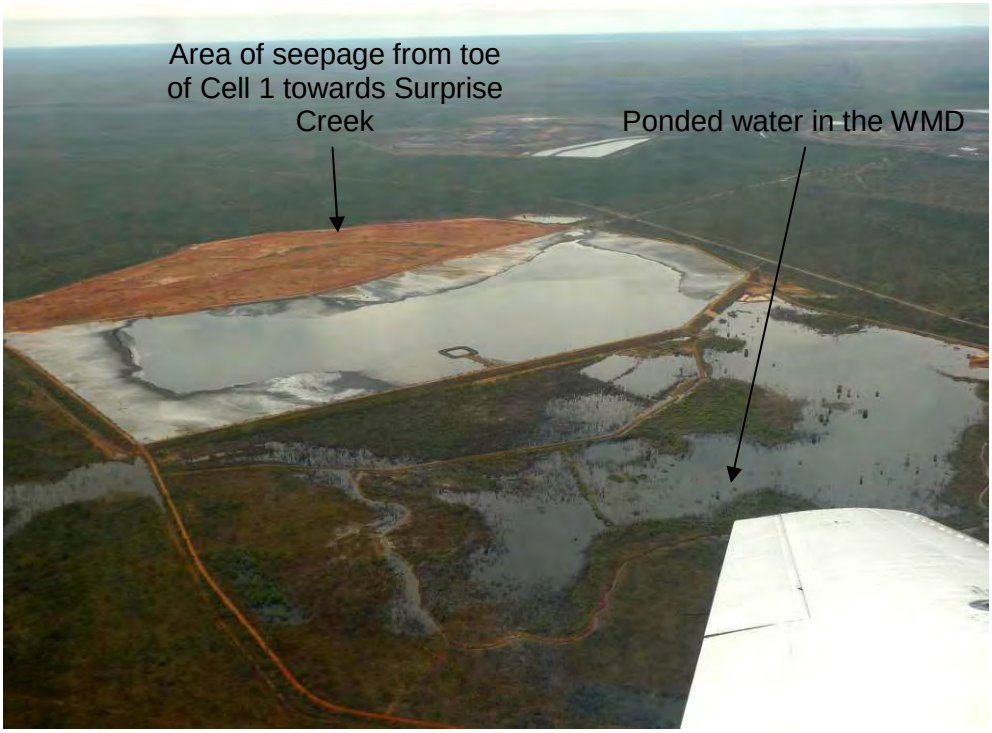


Plate 43 Ponded water within the WMD during the May 2012 site inspection.

It is the opinion of the Independent Monitor that a paleochannel connects the seepage area at TSF Cell 1 near Surprise Creek with the up-gradient upper part of WMD (south of TSF Cell 2); note that this area is within the proposed footprint of the future TSF Cell 3. The improvement in water quality in the seepage from Cell 1 (evidenced by the presence of biota and reduction of visible salt precipitation – chemical data does not appear to be available) would suggest a wide paleochannel connects this upper part WMD with Surprise Creek (underneath the TSF), and that the permeability of the paelochannel is very high (10s of metres per day). The Independent Monitor also considers that infiltration of tailings water (and likely future acid leachate) through the base of TSF 1 and 2 is also a likely scenario, which would mean that an acid and metal front once it has leached through the liner/base of the TSF, could possibly reach Surprise Creek in around 30 days (the water monitoring period) and as quickly as 10 days. For this reason, in its current state, the Independent Monitor currently considers the TSF to be a long term threat to Surprise Creek and downstream. When this potential threat will becomes actual is still unknown.

Planning for the long term acidification of tailings and mitigation of acidic seepage is likely to be the most significant issue for mine closure relating to the TSF.

The Independent Monitor recommendations for the tailings geochemical monitoring are as follows:

- MRM should correct errors in the conceptual model of seepage from TSF Cell 1;
- accelerate leaching trials on current tailings to establish the number of pore volumes required to consume buffering capacity;
- evaluate and design a tailings seepage and closure management system, including in the evaluation the possibility of recovering the tailings from TSF Cell No 1; and
- investigate and discuss when and where seepage will occur from TSF Cell 2, and what the likely impacts will be.

9.10 Review of river diversion hydraulic performance

9.10.1 Review of Sustainable Development Water Management Plan 2011-2012

Diversion Channel As-Built Performance

As detailed in the 2009, 2010 and 2011 Audit reports the Independent Monitor was of the opinion that the as-built diversion channel works should be 'tested' by inserting as-built channel cross sections into the detailed design hydraulic model together with associated reporting as to how the as-built channels compare against the various project commitments and associated design intents.

Related to this – and in response to erosion which had occurred in the respective preceding wet seasons - were the 2009 and 2010 Independent Monitor Audit report recommendations that the overland flow path between the original McArthur River channel and the diversion channel should also be modelled on the basis that such modelling would serve to inform the design of works to address not only historic but also potential erosion impacts.

Whilst we have not sighted any such report having been completed within this current audit period it is acknowledged that MRM did commission WRM Water & Environment to prepare such a report and a draft (July 2012) report has only very recently been submitted to MRM.

Given its draft status, the final version of the WRM report is not reviewed as part of this audit however it is recommended that it be covered in the next audit report.

McArthur River Diversion Channel Erosion

The 2011-2012 WMP report (MRM, 2011) includes a section on diversion channel erosion matters.

Whilst the Independent Monitor has sighted a MRM memo titled 'Scope of Rehabilitation Works for the McArthur Channel' memo dated 27 July 2011, the memo does not cover any erosion control issues associated with the channel itself. The only reference to erosion control in the memo was a proposal to address significant localised erosion which had occurred immediately adjacent to a newly constructed access track along the western edge of the channel. While the Independent Monitor observed during the May 2012 audit inspection that some rock had been placed in the eroded channel, there were several concerns about the then status of the work. That is, the rock had the appearance of having just been dumped and the mounds themselves were both too high to serve as 'check dams', and spaced too far apart to provide an adequate system of addressing future erosion.

With regard to river channel erosion itself, the current WMP report repeats the previous year report's documentation of the photographic reference sites which are spaced at 250 metre intervals. However, there is no evidence that the photographic series has been used to review erosion trends. This situation mirrors past audit findings that despite the taking of photographs after each wet season, none of those historic records have been used to document and/or comment on instances of McArthur River diversion channel bank erosion. Having been provided with a MRM spreadsheet which facilitates a comparison of 2008 and 2011 diversion channel photographs, the Independent Monitor considers that the spreadsheet would have substantially assisted any MRM in-house review and the subsequent generation of review comments for the WMP report. It is noted that some of the 2011 photographs (especially through Chainages 3000m-3500m) appear to have been taken close to sunset and the light and shade conditions are not conducive to producing good quality photographs, with resultant difficulty when trying to compare two sets of photographs. It is recommended that this be considered when future photographs are being taken.

As was reported in the Independent Monitor's 2011 Audit report, MRM had advised the Independent Monitor that the May 2010 ALS/aerial photography would be used to draw comparisons with regard to erosion along both diversion channels. Furthermore, as also addressed in the 2011 Audit report, the Independent Monitor encouraged the use of the accompanying ALS ground truth data to explicitly map changes in the diversion channel batters, etc. It is noted that neither of the above uses of ALS data has been actioned since the current WMP report only makes reference to the use of ALS ground truth data within the March 2010 Connell 'post-construction' diversion channels report.

In addition, and as documented in previous Independent Monitor audits, it is again recommended that the future reporting of erosion trends should include discussion of the relative magnitudes of flows in the preceding wet seasons.

Barney Creek Diversion Channel Erosion

Despite the volume of photographs which had been taken after each of the past few wet seasons the Independent Monitor notes (and as also addressed in the 2010 and 2011 Independent Monitor Audit reports) that there was no evidence of the photographs having been used for this audit period for the documenting of erosion trends along the Barney Creek diversion channel. This is even though – just as for the river diversion - a spreadsheet had been put together by MRM which presented 'paired' 2008 and 2011 photographs. Some of the 2011 photographs (especially through Chainages 250m-1250m) show the channel bank being substantially in shade. Since this is not conducive to producing good quality photographs (with resultant difficulty when trying to compare two sets of photographs), it is recommended that this be considered when future photographs are being taken.

Downstream River Sediment Monitoring

In response to their reading of the 2010 Audit report, MRM had advised the Independent Monitor (reference MRM 24/8/2010 letter to Environmental Earth Sciences) of a number of intended actions, including several relating to the monitoring of the potential sedimentation zone downstream of the diversion. One of those intended actions was that the Environmental Monitoring Technical Manual would be updated to define clearer guidelines for the taking of dry season (low flow) photographs. In their letter MRM recognized that the series of photographs would be a tool for "capturing" sedimentation trends in that section of the river and made the commitment that the trends/changes would be "identified and discussed in future Water Management Plans".

The Independent Monitor also notes that the same commitments were also included in the 2010/2011 MMP report together with a commitment to upgrade the MRM Environmental Monitoring Technical Manual.

However, despite the above commitments, it is noted that the 2011-2012 WMP report includes no commentary on erosion trends in the 'downstream river' reach nor has the MRM Environmental Monitoring Technical Manual been updated.

As was also noted in the 2011 Audit report, it is especially important that the 'downstream river' photographs be taken at a time of very low flow – such that the channel bed is exposed – and that the photographs themselves are taken at exactly the same location and orientation. A review of the MRM spreadsheet which pairs the 2009 and 2011 lower McArthur River chainage photographs shows that the potential change in channel bed conditions cannot be assessed since the bed is not exposed in the 2011 photographs. While it is appreciated that there is a considerable time commitment involved in getting to the 'downstream' reach, etc., the risk of taking photographs at a time when the river level is too high – with resultant questionable usefulness - should be able to be minimised by checking the river station 'real time' water level before making the decision to undertake the trip.

Furthermore with regard to the spreadsheet paired photographs it is clear that some of the pairs either don't represent the same exact opposite bank view (e.g. Chainages 500m & 1500m) or different views are paired (e.g. Chainage 1600m).

9.10.2 Review of Sustainable Development Water Management Plan 2011-2012

As was noted in the 2011 Audit report, the 2010-2011 WMP was seen to be a substantial improvement on the 2009 Water Management Plan.

River Flow reporting

The 2011 Audit report noted that there were a number of apparent anomalies in the high and low flow regimes recorded at the Upstream and Downstream McArthur River gauging stations and also the Barney Creek gauging station and the Early Warning Flood station. It was also noted that the presentation of continuous flow records would be considerably improved by the adoption of the same twelve month time axis plot presentation for all four stations.

While the Upstream and Downstream station plots of water levels and flows in the 2011-2012 WMP appear to be free of the inconsistencies which were noted in the 2011 Audit report, it is noted that the flow patterns remain difficult to compare since the various data sets are still being plotted using differing time axis scales.

Also in the 2011 Audit report it was recommended that the historic wet season peak flows be compared with the average recurrence interval design flows (which were separately presented in the report). The same comment applies to the current WMP report.

Issues related to apparent inaccurate recording of water levels and potential inaccurate conversions to flow were raised (again) in the 2011 Audit report. The Independent Monitor acknowledges that continuing efforts are being made to rectify identified shortcomings in the operation of the various river stations and in the accuracy of their rating tables.

Flood Warning System

In its Section 2, the WMP report describes the current early flood warning system. With regard to this system, each of the 2009, 2010 and 2011 Independent Monitor Audit reports recommended the upgrading of information associated with the Early Flood Warning station. This recommendation was made since although the water level information is readily available for mine personnel to review, the levels by themselves do not allow early identification of potentially critical flooding at the mine. That is, there needs to be a relationship developed which relates water levels recorded at the Early Flood Warning Station to various flood damage/hazard 'bench marks' at the mine.

As was also reported in the 2011 Audit report, the Independent Monitor notes that such a relationship could be facilitated by relating the Early Flood Warning station water level and flow data with the Upstream river station data. The related revisions of both the "Early Flood Warning System Procedure" and the "Site Emergency Response Plan" documents have not been sighted by the Independent Monitor.

In relation to this matter the Independent Monitor has sighted a draft 2011 Xstrata Audit Services report which examines the Water/Wet Weather Management systems at MRM. While the report refers to failure scenarios such as "water flooding the pit" it is unclear whether this is referring to local groundwater inflow situations or overtopping of the mine levee through the passage of a catastrophic flood. Either way, the latter scenario is seen to be a 'significant issue' – and therefore should be recognized as such - given that the early

warning system procedure currently does not have the capacity to provide clear warning of such an event.

Water Management Infrastructure

In previous audits the Independent Monitor had found that successive mining management plans had been lacking in their presentation of evidence of inspections and reporting of sediment trap performance. While the 2011 Audit noted that the 2010-2011 MMP had similarly also made no mention of sediment control monitoring matters, the Independent Monitor reported that such matters were now being reported via the WMP. And indeed in both the 2010-2011 and 2011-2012 WMP reports, matters related to the monitoring of silt traps and other sediment control structures are addressed.

The Independent Monitor notes that while MRM have responded to past audit concerns by introducing a 'work order' system of inspections (under which the inspections would be undertaken during the dry season "or after any rain event"), neither of the above WMP report provides a summary review of the findings from the inspections or the actions that have followed.

In regard to this, the Independent Monitor has sighted copies of inspections undertaken during March to July 2011, November 2011, December 2011, January 2012, February 2012 and March 2012. The documents show that inspections had been undertaken monthly during the dry season and approximately on a fortnightly basis during the wet season months. The apparent adoption of a fortnightly wet season inspection regime is not in accordance with the "after any rain event" WMP commitment and indeed it is noted that the completed inspection forms during those wet months often record nil rainfall during the previous 24 hours. It is important that the wet season inspections be undertaken in response to rainfall events – as per the MRM commitment - rather than on a calendar basis. (It is also noted that a benefit of regularly using staff who are experienced in carrying the inspections should result in wet season inspections which give priority to those structures historically known to have capacity 'issues'.)

While the inspection forms appear to be being well used to record both satisfactory conditions and observed defects in the various traps and dams, it is unclear how noted defects are being responded to. That is, for example, there are some instances where the same comment about the need to clean out trapped silt in a particular structure occurs in consecutive reports so it is unclear whether there has been any action is response to the initial report. In a more obvious case there was one identified urgent need for de-silting yet the Independent Monitor has not sighted any report that the urgent need was addressed and when it was addressed. It is noted that this issue was addressed in the draft 2011 Xstrata Audit Services report's review of MRM's water and wet weather management practices and a resultant action plan, involving records being kept in 'Sitesafe', was documented in that report. One reporting option which may also be considered is the modification of the inspection form (VI0016) to include an 'action' column so that there is a record that the defect or desilting need, etc has been addressed.

As per previous audit report recommendations, it is again recommended that the WMP report upgrade the map (i.e. current Figure 3-3) to show the location of all silt traps and sediment dams, etc.

Water Balance Modelling

The 2011-2012 WMP report advises that the OPSIM-based water balance modelling (which had been utilised since 2001) had been replaced by Goldsim-based modelling. The report states that the work (which has been undertaken by WRM Water & Environment) included calibration of the model using historic data, updating the overall MRM water balance model to reflect the September 2011 system configuration and the projection of revised estimates of the long term operational characteristics.

The WMP report provides only limited details regarding the Goldsim model, including the following outputs:

- The results of the calibration exercise in reproducing the July 2010-June 2011 water levels in the open cut mine, the Water Management Dam and Cell 2 of the Tailings Storage Facility; and
- the results of modelling four water balance scenarios; that is, the 2010/2011 year, a representative dry (i.e. 90% percentile) year, a representative median year and a representative wet (i.e. 10% percentile) year.

With regard to the above four water balance scenarios, it is noted that the modelling has determined that the 2010/2011 year was much wetter than the (10 percentile) wet year.

The Independent Monitor has sighted a 2011 Hatch report which reviews one of the most critical parts of the mine's water resources regime; that is, the inflow regime to the open pit. While the Hatch report recommends re-calibration of the then OPSIM model, it is assumed that the latest data has been/will be incorporated into the replacement Goldsim model.

Regarding the documentation of the Goldsim mine model, it is recognised that significant details are provided in a 2012 WRM report which examines a range of surface water issues related to the proposed Phase 3 development.

Bing Bong Port water management improvements

The long term Bing Bong Site runoff regime has recently seen some significant improvements in terms of runoff control and both of these are documented in the WMP 2011-2012 report.

Firstly, the original runoff pond has been supplemented by two overflow dams which were constructed before and after the 2010/2011 wet season. The Independent Monitor concurs with the construction of additional storages but has not sighted any report which determined the required dam sizes.

Secondly, the report refers to a proposal to upgrade the roof runoff system for the 6000 square metre concentrate storage shed whereby the system would send first flush flows to the runoff pond while the subsequent flows (which will account for most of the roof runoff) would be piped to the sea. During its May 2012 inspection the Independent Monitor observed that the works had been completed. While the team has sighted layout drawings for the new roof runoff collection system, the supporting hydrologic design calculations have not been sighted.

While Goldsim Bing Bong summary tables have been sighted for the same four water balance scenarios examined at the mine site, the Independent Monitor has not sighted any supporting documentation regarding the Bing Bong model. It is therefore unclear whether the summary tables reflect the actual pond storages which were operating during the 2010/2011 wet season, etc. Just as for the mine site model, it is noted that the Goldsim model of Bing Bong has determined that the 2010/2011 year was much wetter than the (10 percentile) wet year.

McArthur River Extractions

The 2010 Audit report recognized that the water extraction system changed in March 2010 when the irrigation sled system came into operation but also identified improvements that were considered necessary to the system of reporting the flows extracted from the river. Principally the recommendations concerned the documentation of coincident river level/flow rate on the reporting form together with the recording of each period of pumping (rather than just the reporting of weekly totals).

The 2011-2012 WMP report lists the flows which were extracted during the 2010 dry season and also states that up to the time of report preparation no water had been extracted during 2011. However the report makes no reference to any changes in the reporting of extracted flows.

Conclusion

In the 2011 Audit report, the Independent Monitor recognized that in many ways the WMP 2010-2011 report was a far more complete document than the earlier WMP reports.

Whilst that audit report recommended that a number of 'water management' reporting comments be addressed in future WMP reports, it is noted that most of the review comments have not been incorporated into the latest WMP report.

9.10.3 Documentation of Diversion Channel Construction Works

Construction Reporting

In the 2009 Audit report it was reported that details of the construction process had not been sighted and furthermore it was recommended that hydraulic modelling of the as-constructed diversion works should be undertaken.

The 2010 Audit report subsequently reviewed a March 2010 Connell Hatch 'post-construction' report titled "Construction Report – Levee & Diversions McArthur River Mine Expansion Project". A number of concerns were included in the audit report about the lack of construction detail in the reporting of both the river and creek diversions.

The 2011 Independent Monitor Audit report text advised that the Independent Monitor had not sighted any response from MRM re those concerns. This is still the situation.

Future Reporting

As documented in the 2010 and 2011 Audit reports, there was a Public Environmental Report (PER) commitment that a series of river diversion reports would be prepared. Given the project timeframe, one of those reports was due in 2011. In the 2011 Audit report it was recommended that various shortcomings be addressed. Apart from the draft July 2012 WRM report (which appears to focus solely on the 'hydraulic' performance of the McArthur River and Barney Creek diversions), the Independent Monitor has not sighted any report which holistically examines the as-built performance of the diversions.

9.10.4 Diversion channel observations

McArthur River Channel

The May 2012 Independent Monitor site inspection, the inspection covered from Chainage 0m to about Chainage 4000m and there appeared to be no significant new erosion issues as a consequence of the 2011/2012 wet season.

In 2010, works were undertaken (as reported in the 2011 Audit report) to address substantial scour issues associated with the overland flow path between the old river channel and the diversion channel (between approximate river Chainages 500m– 600m). The Independent Monitor has observed that those works have coped well with both the 2010/2011 and 2011/2012 wet season flood flows.

As was also similarly reported in the 2011 Audit report, significant deposits of sand were observed at a number of eastern bank chute locations. At those locations it was difficult to ascertain if the sand represented a deposition of material on top of the original scour protection rock work or whether some of the rock works had been washed away leaving behind rock remnants which then had been subsequently covered with sand. As was also recommended in the 2011 Independent Monitor Audit report, all chutes should be assessed after each wet season in order to determine if there is a need for additional/replacement scour protection works.

Barney Creek Channel

The Barney Creek diversion channel was inspected from its upstream end to the confluence with Surprise Creek and in the vicinity of where the OEF haul road crosses the channel.

There were no signs of any recent erosion.

Diversion Channel Erosion Reporting

As noted elsewhere in this report the Independent Monitor considers that future WMP reports should reflect prior MRM commitments to the use of the aerial photography/ALS data as well as the reviewing of successive series of 250 metre interval photographs to report on on-going, or new, erosion areas.

It is anticipated that the future WMP reports will also provide some initial McArthur River western batter and Barney Creek southern batter comments following the commencement of 'opposite bank' photography by MRM.

9.10.5 Overview of the past five years of river diversion performance monitoring

As-Built Diversion Channel Performance

The Independent Monitor has had on-going concerns with regard to areas of the performance of the diversion channels. They relate to the lack of details regarding the construction phase, the lack of 'verification' flood modelling and the lack of monitoring/reporting of erosion matters.

All of the above three items remaining outstanding although it is recognised that the second item has been the focus of a very recent WRM Water & Environment report (and which, due to its current draft status, will be reviewed in the next audit period).

With regard to the third item, it is disappointing that very considerable and worthwhile amounts of collected/acquired data – i.e. the history revealed through regular series of 'opposite bank' photographs and the commissioned aerial photography/ALS ground levels – is not being used to either assess and/or monitor sedimentation and erosion trends (including along the river downstream of the river diversion).

Monitoring of Silt Traps and Sediment Dams

The Independent Monitor has had on-going concerns about the monitoring and reporting of the performance of the network of silt traps and sediment dams. While it is recognised that improvements have been made, especially in the area of monitoring, there are still – as documented in this Audit report - several significant shortcomings in the monitoring and reporting processes.

Flood Risk Management

The Independent Monitor has expressed on-going concerns regarding the failure of the current flood warning system to be able to provide early warning of a potentially catastrophic flood. Given the obvious risks in terms of personnel safety and damage to mobile plant etc. of a very rare but potentially high hazardous floodwaters inundating major parts of the mine, especially the open pit, it has been regularly recommended that the data from the Early Warning river station be used to develop a procedure which informs the necessary management personnel that such a flood – or similar - is approaching the mine.

Given the risks associated with catastrophic flooding, this outstanding matter remains of considerable concern.

'Low Flow' Extractions from the McArthur River

The Independent Monitor has expressed on-going concerns about inadequacies in the method of reporting when water is extracted from the river during the dry season.

While some improvements have been made it is still seen to be highly desirable for the reporting process to explicitly show that the pumping takes place in accordance with the extraction license. It is considered that this can only occur when the coincident river flow conditions – i.e. the water level and corresponding flow at the Upstream River gauging station – are reported during each period of pumping.

10 SUMMARY OF RECOMMENDATIONS

Table 16 below provides a summary of specific recommendations given by the Independent Monitor this audit period. A priority level has also been advised for recommendations.

TABLE 16 SUMMARY OF RECOMMENDATIONS

Surface water monitoring – Section 9.1.3	**Priority level**
Adjustments to the surface water monitoring program should be implemented by adding sampling points on the drainage line where the seepage from the Northern OEF was reported. In addition, the seepage observed from the western toe of the OEF during the May 2012 inspection should also be included in the monitoring program for surface waters.	HIgh
Aspects of the QA/QC reporting in the WMP should include comparison of field to laboratory results, in particular: • TDS/EC ratio (acceptable range of 0.55-0.80); • field pH to laboratory pH relative percent differences (RPDs), with an acceptable RPD of 10%; • RPD between field collected blind (intra-laboratory) duplicate samples and split (inter-laboratory) duplicate samples, including presentation and discussion of results and elevations in RPDs in particular; and • discussion of findings of the laboratory's quality control reporting.	Low to Medium
Groundwater monitoring – Section 9.2.11	**Priority level**
Borefields: • monitoring water levels in borefield abstraction and surrounding observation bores prior to, during, and following cessation of pumping cycles (installation of pressure transducer data-loggers in at least some wells would be advantageous); • constructing hydrographs of pressure levels in all borefield abstraction bores and nearby observation bores, including rainfall and abstraction volumes and rates; • assessing data such as recovery rates following cessation of pumping and drawdown rates during constant discharge.	Low
OEF: • hydrographs be constructed for monitoring bores GW64S, GW64D, GW65S and GW65D to allow assessment of changes in groundwater pressure over time; • installation of nested monitoring bores (as with GW64 and GW65) be considered in the northern and eastern OEF where seepage is currently occurring.	Medium
TSF: • as over 500 m^3 of hydrocarbon impacted soil has been taken to the TSF waste emplacement facility, bores GW4, GW6, GW14 and GW18 as a minimum should be monitored for TPH/ BTEX/ naphthalene (if not already done so); • combining hydrogeological and hydrogeochemical data and development of a conceptual model for the TSF based on this data (updated annually).	Medium
Hydrocarbon infrastructure monitoring/ management: • 'actioning' of the items recommended in the Coltech Planning Pty Ltd Engineering report 20 October 2011; • installation of a high level alarm on aboveground diesel tanks; • sealing and integrity testing of bund walls and floors for all hydrocarbon storage facilities; • improvements to fencing technology to keep stock and other fauna off the mine site.	High

Aspects of the QA/QC reporting should include discussion on comparison of field to laboratory results, in particular: • TDS/EC ratio (acceptable range of 0.55-0.80); • field pH to laboratory pH relative percent differences (RPDs), with an acceptable RPD of 10%; • RPD between field collected blind (intra-laboratory) duplicate samples and split (inter-laboratory) duplicate samples, including presentation and discussion of results and elevations in RPDs in particular; and • discussion of findings of the laboratory's quality control reporting.	Medium
Recommendations for groundwater monitoring analytical suite include: • analysis for metals be limited to dissolved species including dissolved Al, Fe and Mn; • a full cation and anion ionic balance be undertaken on all samples (pH, TDS, Na, Ca, Mg, K, Cl, SO_4, HCO_3, NH_3, NO_3, NO_2, PO_4 and F).	Medium
Recommendations for interpretation and reporting: • Groundwater contours should be interpreted for each separate formation, but particularly the bedrock and the alluvium, need to be presented at least bi-annually (at the end of wet and end of dry seasons). These can also be used as a check against the predicted drawdowns in the updated URS groundwater model (URS January 2012). • Separate groundwater contour figures using all available bores should be provided for the TSF, the regional monitoring network and Bing Bong, as well as the OEF once further bores are installed. These will enable greater interpretation of groundwater flow direction(s) and hydraulic gradients and, in turn, provide visual representation of the significant factors in groundwater impacts from the MRM operations. This is a recurring recommendation by the Independent Monitor and is yet to be adequately addressed.	Medium
Dust Monitoring – Section 9.3.7	**Priority level**
• Continual increases in dust mitigation measures at Bing Bong and PACRIM/ROM pad; • ensure that QA/QC documentation is always obtained from laboratory conducting dust analyses; and • address minor reporting issues outlined in Section 9.3.	Medium
Soil Monitoring – Section 9.4.4	**Priority level**
Consideration should be given to undertaking soil sampling in areas outside the mining lease, ideally in both upwind and downwind locations, to assess whether any mining impacts are occurring outside the mine site due to wind or water transport and deposition.	Low
Soil monitoring data should be correlated with sediment monitoring data in the MMP.	Medium
Soil monitoring program recommendations: • Refine analytical suite and interpretation of data; • Increase spatial density of sampling program (at least every five years) or alternatively undertake delineation sampling of areas with increase metal concentrations; and • develop site-specific trigger levels.	Medium

Fluvial Sediment Monitoring – Section 9.5.5	**Priority level**
Regarding the fluvial sediment monitoring and reporting, MRM should: • Address elevated metal concentrations within Barney Creek sediments by implementing the planned mitigation measures; • Include a discussion for all parameters analysed; • Include QA/QC samples (namely duplicates and splits) to add robustness to data; and • Incorporate background sediment levels determined by the macroinvertebrate assessment as long term targets.	Medium
Seawater and Marine Sediment Monitoring – Section 9.6.6	**Priority level**
Key recommendations for seawater and marine sediment monitoring and reporting: • include QA/QC samples (namely duplicate and splits) in the regular seawater and sediment programs; • upgrade DGT monitoring QA/QC procedures; • include presentation of trends for sediment monitoring results; • include assessment of sediment samples from transects outside the swing basin; and • include lead isotope analysis of suspended sediments from the water column in the McArthur River delta region.	Medium to high
Mine site flora monitoring – Section 9.7.3	**Priority level**
More focus on planting of targeted species Freshwater Mangrove *Barringtonia acutangula* and Native Cane Grass *Chionachne cyathopoda*	Medium
Increase planting on bank slopes of river diversions.	High
Expand vegetation monitoring carried out by CDU on the McArthur River diversion to include additional sites to allow representation of the entire length of the channel.	Medium
Incorporate additional analogue sites into the survey design for vegetation monitoring at Barney Creek. The current analogue site located on Surprise Creek is unsuitable due to its location on a different system and its position downstream of the tailings dam.	Medium
Increase weed control on the opposite bank of the McArthur River diversion.	High
Conduct trials on the survival of different riparian species at different levels on the bank slopes to allow selective planting.	Medium
Conduct monitoring on heavy metals in vegetation in McArthur River and Barney Creek to investigate uptake of metals as a result of mine operation.	Low
Investigate the possibility of conducting a combined weed control program with pastoral properties on the McArthur River, upstream of the mine. This will help to stop the re-infestation of weed controlled areas from infestations further upstream (outside of operational areas) and will promote community relations.	Medium
Consider relocating the remainder of the cattle exclusion fencing along McArthur River diversion to higher ground to decrease chances of it being breached during the wet season.	High
Replace barbed wire in fencing with plain wire as barbed wire catches debris in high flood periods, weighing the fence down and causing it to become dislodged.	Medium
Remove old cattle exclusion fencing along McArthur River diversion as it poses a hazard to fauna and MRM personnel.	Low
Conduct bi-annual vegetation monitoring at Surprise Creek to evaluate effects of tailings leachate.	Medium

Expand information regarding rehabilitation in Table 3.1 in 2011/2012 MMP to include areas which will require rehabilitation in the future.	Low
Improve topsoil map to make it clearer where topsoil is stockpiled along the river diversions.	Medium
Mine site fauna monitoring – Section 9.7.4	**Priority level**
Increase density of the important riparian plant species; Native Cane Grass, Freshwater Mangrove and *Pandanus* along the river diversions.	High
Ensure cattle are excluded from restoration areas along the diversions.	High
Continue to monitor and add large woody debris annually.	High
Include molluscs in metal analysis of biota in river diversions, if possible, as they are good indicators of metal contamination.	Medium
Make fish monitoring in Surprise Creek and Little Barney Creek an annual event to investigate further the effect of sulphates and metals on fish from tailings seepage.	Medium
Conduct fish monitoring on Barney Creek within the diversion and on undisturbed stretches to evaluate the effect of the diversion on fish assemblages.	Medium
Conduct ecotoxicology evaluation that includes a suite of tropical native species as part of test design in order to create a more robust dataset (Hydrobiology, 2011).	Low
Bing Bong Port Flora Monitoring – Section 9.7.5	**Priority level**
Investigate alternative options for dredge spoil rehabilitation trial as a monitoring gap has now existed for a number of years.	High
Conduct monitoring of vegetation surrounding the dredge spoil spoon drain experiencing vegetation dieback.	Medium
Spoon drain maintenance works should be carried out annually to remedy damage caused by erosion and cattle.	High
Exclude cattle from dredge spoil area.	Medium
Continue with weed control program in place.	High
Bing Bong Port Fauna Monitoring – Section 9.7.6	Priority level
Include monitoring of mosquito larvae in artificial ponding areas, three days after large wet season rains in the annual mosquito monitoring program (Department of Health, 2011).	Low
Incorporate the insertion of drainage holes in Waste tyres into the Waste Tyres and Conveyor Belt Procedure.	Low
Rectify ground depressions by inserting drains and/or infilling, where possible.	Low
If not already in place, an insecticide spraying register should be kept to assess areas and times of year that spraying is conducted.	Low
Extend survey area to the Limmen Bight River in bi-annually migratory bird surveys as it appears to be a significant area for migratory species.	Low
Marine Biota Monitoring – Section 9.7.7	**Priority level**
Establish control sites for seagrass monitoring.	Low
Use data from the Yanyuwa IPA, Barranyi National Park and Limmen Bight Marine Park as control data in Marine monitoring program particularly in the sea grass monitoring.	Low
In the annual marine report, categorise oysters as bivalves and *Telescopium telescopium* and *Terebralia semistriata* as gastropods as both as molluscs and this can cause confusion.	Low

Continue to observe trends regarding the presence of heavy metal in sediments on the beach west of the loadout facility.	Medium
Tailings Storage Facility – Geotechnical monitoring – Section 9.8.1	**Priority level**
Still outstanding from the 2011 Audit, Installation of piezometers in embankments and comprehensive dam safety review including stability analysis of the embankments, especially the Southern Embankment of Cell 2 where water is ponding against the embankment.	High
A review of available capacity to store tailings, process water and rainfall runoff whilst maintaining sufficient freeboard also taking into account the initiative to increase evaporation by using a larger part of the WMD. A review of the water balance including detailed water balance modelling should be carried out.	High
Following a water balance review, excess water to be removed from the facility.	High
The pipeline on ramp to TSF should be bunded or secondary containment pipe installed.	Medium
As part of the proposed 4m raise, detailed stability analyses needs to be carried out, which includes monitored (as opposed to estimated) information regarding the phreatic surfaces in the tailings and embankments.	High
Tailings Storage Facility – Geochemical monitoring – Section 9.9.3	**Priority level**
MRM should correct errors in the conceptual model of seepage from TSF Cell 1.	High
Accelerate leaching trials on current tailings to establish the number of pore volumes required to consume buffering capacity.	Medium
Evaluate and design tailings seepage and closure management system, including in the evaluation the possibility of recovering the tailings from TSF Cell No 1.	High
Investigate and discuss when and where seepage will occur from TSF Cell 2, and what the likely impacts will be.	High
Overburden Emplacement Facility – Geotechnical monitoring – Section 9.8.2	**Priority level**
Technical specification for clay placement required and higher level of supervision for clay placement.	High
Application of the MRM standards and correlation of those standards to the original URS design requirements. Confirmation that the testing density and sample density is adequate and in line with best practice and standards.	High
Inclusion of liner testing in the geotechnical reporting.	Medium
Construction of top cover over OEF prior to wet season.	High
Overburden Emplacement Facility – Geochemical monitoring – Section 9.9.2	**Priority level**
A review of the classification of NAF waste is required as the sulfur content is very high—often >5% total S.	High
Review the mineralogy of the NAF, PAF and AC waste to determine what minerals are present, including carbonates, dolomites, sulfides and sulfates. It is noted that there are a lot of carbonate nodules present in the host rock sequence and the lead zinc deposits are known to contain siderite and manganese siderite. Both these carbonates are net neutral, therefore it is possible that the acid neutralisation capacity maybe overstated. However, the acid neutralisation capacity is easy to check by undertaking a mineralogy investigation of the potential waste rock (NAF/AC) and using the correct ANC analysis to account for the presence of siderite.	High
The Independent Monitor has previously recommended the construction of larger kinetic cells or columns on site, to account for the fact that the laboratory based leach columns test only one range of particle size: <5-10 mm. The surface area of the current column material is significantly higher than what is generated during mining and may not be a true reflection of the reactivity of the waste rock types under oxidising conditions.	High

Review and analyse selected waste rock samples for sulfide sulfur (e.g. using the Chromium Reducible Sulfur or CRS method) as well as total sulfur. All hanging wall material should be considered to be PAF.	High
Due to the commencement of seepage from the NOEF along the northern and eastern edges of the facility (see MRM Memorandum dated 15 March 2012), the Independent Monitor recommends the consideration of placement of nested piezometers in these locations. If installed, these bores should be incorporated into the current water quality monitoring program (as per MRM WMP 2011/2012). In addition, Metserve (2012) recommends a monitoring program for the OEF soil, surface water, groundwater and sediment (Table 6-1, ppE2-42-43). For the groundwater and surface water parameters, the Independent Monitor has the following recommendations/ suggestions: • filtered metals and metalloids also include Al, Fe, Mn and Se; • cations include NH_4-N; • anions include HCO_3 (alkalinity), NO_3, NO_2, PO_4 and F, in addition to Cl and SO_4; and • total metals can be removed from the groundwater suite.	High
Bing Bong Dredge Spoil – Geotechnical monitoring – Section 9.8.4	**Priority level**
• Geotechnical review of embankment stability required prior to wet season (this is assumed to be taking place in the latter half of 2012). • Installation of piezometers and survey monument and a geotechnical monitoring program to be instigated. • Installation of engineered spillway required before wet season.	High

11 CONCLUSIONS

The Independent Monitor is of the opinion that the general environmental performance of the Mcarthur River Mine has improved over the past five years of monitoring. This Audit period, the Independent Monitor has observed improvements relating most notably to:

- the level and detail of reporting presented within the 2011/2012 MMP and WMP;
- dust mitigation and monitoring at the Mine site; and
- ongoing rehabilitation of the McArthur River Diversion.

Monitoring of flora and fauna, structural monitoring of the river diversions, surface water, and fluvial sediment have continued to be appropriate this audit period.

The significant issues of concern identified within this Audit report for the 2011 Operational Period included:

- the volume of water stored in Cell 2 of the Tailings Storage Facility (TSF) and the;
- delineation of seepage at the TSF, and its affect on Surprise Creek;
- progress of acidification of the tailings and delineation of the treatment options;
- identification and management of Potentially Acid Forming (PAF) rock waste at the Overburden Emplacement Facility (OEF); and
- progress of revegetation on the McArthur River diversion, particularly along downstream sections.

These issues of concern were also identified as part of the previous Independent Monitoring audit undertaken in 2011. We note that while MRM have indicated a willingness to address these issues, significant works are still required to mitigate the potential environmental risks associated with these issues. We commend MRM for their efforts towards increasing the environmental performance of the operation over the past five years, and encourage an ongoing proactive commitment to increasing their environmental performance.

12 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:

- The Independent Monitor Assessment Conditions (IMACs);
- The specific scope of services set out in the contract issued by the Department of Mines and Energy– Document KO7-0065;
- 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;
- 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;
- 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"); and
- 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.

13 REFERENCES

ANZECC (2000) *Australian and New Zealand guidelines for fresh and marine water quality*. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

ANZFS. 2009. *Australia New Zealand Food Standards Code 53*. Standard 1.4.1. Contaminants and natural toxicants. Issue 111.

BMT WBM (2012) *Bing Bong Loading Facility Annual Seagrass Monitoring – 2011 Episode.* Prepared by BMT WBM Pty Ltd for McArthur River Mine Pty Ltd. January 2012.

BMT WBM (2011) *Seagrass Monitoring of Port Bing Bong – November 2010*. Prepared for McArthur River Mining Pty Ltd.

CDU (2011) *Assessment of vegetation development associated with the Barney Creek and McArthur River diversions, 2011 report.* Report to McArthur River Mining. School of Environmental and Life Sciences, Charles Darwin University.

Connell Hatch (2010) Construction Report – Levee & Diversions McArthur River Mine Expansion Project.12 March 2010 (Revision A).

Department of Health (2011) *Mosquito Monitoring Program McArthur River Mine 2010/11*. Medical Entomology Centre for Disease Control, Department of Health, July 2011.

Department of Sustainability, Environment, Water, Populations and Communities (2012) *Yanyuwa- Indigenous Protected Areas Fact Sheet*. Commonwealth of Australia, May 2012.

EES (2011) *Independent Monitor's Audit of the McArthur River Mine for the 2010 Operational Period. Report to the Minister for Primary Industry Fisheries and Resources, Version 1. Report no. 211011* Prepared by Environmental Earth Sciences, Victoria. October 2011.

EES (2010) *Independent Monitor's Audit of the McArthur River Mine for the 2009 Operational Period. Report to the Minister for Primary Industry Fisheries and Resources,* Prepared by Environmental Earth Sciences, Victoria. October 2010.

EMS (2012a) *McArthur River Freshwater Aquatic Macroinvertebrate Assessment 2011, Revision 1.* Prepared by Paul Barden, Ecological Management Services, January 2012.

EMS (2012b) *McArthur River Riparian Bird Monitoring*, *September 2011* Revision 1, Report prepared by Paul Barden, Ecological Management Services, January 2012.

EMS (2011a) *Survey of Listed Migratory Shorebirds and Other Birds, Port McArthur Area, Summer*, 2011. Report prepared by Paul Barden and Dr John Coleman, Ecological Management Services, March 2011.

EMS (2011b) *Survey of Listed Migratory Shorebirds and Other Birds Port McArthur Area, Northern.*

Staging Migration, April 2011, Report prepared by Paul Barden and Dr John Coleman, Ecological Management Services, May 2011.

EMS (2011c) *McArthur River Riparian Bird Monitoring*, *May- June 2011,* Report prepared by

Paul Barden, Ecological Management Services, November 2011.

Hatch (2011) *Water Balance Review*. Dated 26 May 2011.

Hydrobiology (2011) *Ecotoxicity Evaluation of McArthur River Mine Levee Water, 2011 Ecotoxicity Report*. Hydrobiology, April 2011.

Indo-Pacific Environmental (2012) *Interim Report on the Aquatic Fauna of the McArthur River*, *Northern Territory, October 2011*, Report prepared by Dean Thorburn, January 2012.

Indo-Pacific Environmental (2011a) *Interim Report on the fish and other Aquatic Fauna of the McArthur River*, *Northern Territory, May/June 2011,* Report prepared by Dean Thorburn, October 2011.

Indo-pacific Environmental (2011b) *Survey of Fish of Surprise and little Barney Creeks, September 2011.* Report prepared by Dean Thorburn, September 2011.

Lamche, G. (2007). *The Darwin-Daly regional AUSRIVAS models – Northern Territory. User Manual.*

Report 06/2007D. Aquatic Health Unit, Environment Protection Agency Program, Department of Natural Resources, Environment and the Arts, Darwin.

Metserve (2011) *Ecotoxicology of Sulphate on Aquatic Biota in Surprise Creek at McArthur River Mine, NT*. Mining and Energy Technical Services Pty Ltd. October 2011.

MRM (2011) *Sustainable Development Mining Management Plan, 2011-2012*, Issue 5, Revision 0, 256 Pages, GEN-HSE-PLN-6040-0003, McArthur River Mining Pty Ltd, November 2011.

MRM (2011) 2011/2012 *Sustainable Development Water Management Plan*, Issue 3, Revision 1, 315 pages, GEN-HSE-PLN-6040-0004, McArthur River Mining Pty Ltd, August 2011.

MRM (2011) *Weed Management Plan 2011-2012*, Issue 2, Revision 0, 100 pages, GEN-HSE-PLN-6040-006, McArthur River Mining Pty Ltd, July 2011.

MRM (2011) *File note- MRM Tailing's Dam Cell 1 Direct seeding 2011*. Prepared by McArthur River Mine. March 2011.

MRM (2011) *File note- MRM diversion tree planting trial #1, 2011*. Prepared by McArthur River Mine. January 2011.

MRM (2011) *Large Woody Debris Placement -McArthur River Channe,* Issue 1, Revision 0, 24 pages, GEN-ENV-RPT-6040-0003, McArthur river Mining Pty Ltd, December 2011.

MRM (2011) *Technical Manual for Environmental Monitoring*. Approved 11 2011.

MRM (2011) *Site Emergency Response Plan 2011-2012*. Approved Nov 2011.

MRM (2010) *Sustainable Development Mining Management Plan, 2010-2011*, Issue 4, Revised, 225.Pages, GEN-HSE-PLN-6040-0003, McArthur River Mining Pty Ltd, October 2010.

MRM (2010) *Sustainable Development Water Management Plan 2010-2011*. Approved August 2010.

MRM (2009) *Mining Management Plan 2009-2010*, Issue 3, Revision 0, 162 pages Reference GEN-HSE-PLN-6040-0003, McArthur River Mining Pty Ltd, December 2009.

MRM (2009) *Early Flood Warning System Procedure*. Approved March 2009.

Parks and Wildlife Commission of the Northern Territory (2012a) *Barranyi (North Island) National Park – Fact Sheet*. Northern Territory Government.

Parks and Wildlife Commission of the Northern Territory (2012b) Limmen Bight Marine Park-Fact Sheet. Northern Territory Government.

Tsang J.J. and Parry, D.L. (2012*). Monitoring of bioavailable metal concentrations in seawater by Diffusive Gradients in Thin-films (DGTs) at the XstrataZinc McArthur River Mine loading facility at Bing Bong. Review of 2011-12 data.* Report for XstrataZinc McArthur River Mine. Australian Institute of Marine Science, Darwin. (45 pp.).

Streten-Joyce, C. and Parry, D.L. (2012). *McArthur River Mine: Annual marine monitoring program: 2011*, Report to Xstrata Zinc McArthur River Mine Australian Institute of Marine Science, Darwin.

WRM Water & Environment (2012) *Review of the 'As-Designed' and 'As-Constructed' McArthur River and Barney Creek Diversions*. Draft. 13 July 2012.

WRM (2012) *McArthur River Mine Phase 3 Development Project Surface Water Assessment*. January. Commissioned by Mining and Energy Technical Services Pty Ltd.

Xstrata (2011) *Xstrata Zinc Australia McArthur River Mining Water/Wet Weather Management Review*. Prepared by Xstrata Audit Services. Draft October 2011 report.

14 GLOSSARY OF TERMS

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

Abiotic. Not involving biological activity.

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 $CaCO_3$.

Acid Sulfate Soil (ASS). A soil containing iron sulfides deposited during either the Pleistocene or Holocene geological epochs (Quaternary aged) as sea levels rose and fell.

Acidify. An addition of acid to lower pH.

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

Aquifer. A 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.

Background. The natural level of a property.

Baseline. An initial value of a measure.

Bioremediation. The use of naturally occurring micro-organisms for the restoration of polluted environments, in particular of contaminated land, and/or the groundwater associated with it.

Bore. A hydraulic structure that facilitates the monitoring of groundwater level, collection of groundwater samples, or the extraction (or injection) of groundwater. Also known as a well, monitoring well or piezometer, although piezometers are typically of small diameter and only used for measuring the groundwater elevation or potentiometric surface.

Borehole. An uncased well drill hole.

Buffer. An 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.

Cation Exchange Capacity (CEC). The 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. A soil material composed of particles finer than 0.002 mm. When used as a soil texture group such soils contain at least 35% clay.

Composite sample. The bulking and thorough mixing of soil samples collected from more than one sampling location to form a single soil sample for chemical analysis.

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 that is confined between two low-permeability aquitards. The groundwater in these aquifers is usually under hydraulic pressure, i.e. its hydraulic head is above the top of the aquifer.

Confining layer. A layer with low vertical hydraulic conductivity that is stratigraphically adjacent to one or more aquifers. A confining layer is an aquitard. It may lie above or below the 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. A 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. A 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 hydraulic head.

Electrical Conductivity (EC). The EC of water is a measure 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.

Flow path. The direction in which groundwater is moving.

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

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

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

Groundwater. The water held in the pores in the ground below the water table.

Groundwater Elevation. The elevation of the groundwater surface measured relative to a specified datum such as the Australian Height Datum (mAHD) or an arbitrary survey datum onsite, or "reduced level" (mRL).

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

Head space. The air space at the top of a soil or water sample.

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).

Hydraulic Conductivity (*K*). A coefficient describing the rate at which water can move through a permeable medium. It has units of length per time. The units for hydraulic conductivity are typically $m^3/day/m^2$ or m/day.

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

Hydraulic Gradient (*i*). The rate of change in total head per unit of distance of flow in a given direction – the direction is that which yields a maximum rate of decrease in head. Hydraulic Gradient is unitless.

Hydraulic Head (*h*). The sum of the elevation head and the pressure head at a point in an aquifer. This is typically reported as an elevation above a fixed datum, such as sea level.

Hydrocarbon. A 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.

***In situ* bioremediation.** Bioremediation of contaminated soil or (ground)water undertaken without excavation (i.e. removal); literally "Bioremediation in place".

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

Injection well. A 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.

Iron concretions. The accumulation of dissolved iron which results in the formation of soft to hard orange to red to maroon nodules, can be diffuse of concentrated. A result of periodic wetting and drying.

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

Massive. Refers to the condition of the soil layer in which the layer appears to be as a coherent or solid mass which is largely devoid of peds.

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

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

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

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. Was 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.

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

Permeability (*k*). Property of porous medium relating to its ability to transmit or conduct liquid (usually water) under the influence of a driving force. Where water is the fluid, this is effectively the hydraulic conductivity. A function of the connectivity of pore spaces.

Piezometric or Potentiometric Surface. A surface that represents the level to which water will rise in cased bores. The water table is the potentiometric surface in an unconfined aquifer.

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

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

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). The pumping out of 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.

Putrescible waste. Food waste, waste consisting of animal matter (including dead animals or animal parts) or biosolids categorised as Stabilisation Grade C in accordance with the criteria set out in the Biosolids Guidelines.

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

Remediation. The 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.

Siderite. A 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.

Standing Water Level (SWL). The depth to the groundwater surface in a well or bore measured below a specific reference point – usually recorded as metres below the top of the well casing or below the ground surface..

Stratigraphy. A 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.

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 Dissolved Salts (TDS). The total dissolved salts comprise dissociated compounds and undissociated compounds, but not suspended material, colloids or dissolved gases.

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

Transmissivity. The 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.

Volatile. Having a low boiling or subliming pressure (a high vapour pressure).

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

Well. A hydraulic structure that facilitates the monitoring of groundwater level, collection of groundwater samples, or the extraction (or injection) of groundwater. Also known as a Bore.

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. Client may distribute this report to other parties and in doing so warrants that the report is suitable for the purpose it was intended for. 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 contaminated soil and or groundwater. However, contaminants may be present in areas that were not investigated, or may migrate to other areas. Analysis cannot cover every type of contaminant that could possibly be present. When combined with field observations, field measurements and professional judgement, this approach increases the probability of identifying contaminated soil and or groundwater. Under no circumstances can it be considered that these findings represent the actual condition of the site at all points.

Environmental studies identify actual sub-surface 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 our services.

Problems with interpretation by others

Advice and interpretation is provided on the basis that subsequent work will be undertaken by Environmental Earth Sciences VIC. This will identify variances, maintain consistency in how data is interpreted, conduct additional tests that may be necessary and recommend solutions to problems encountered on site. Other parties may misinterpret our work and 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 ASSESSMENT TABLE

TABLE 17 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

TABLE 18 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.

TABLE 19 KEY TO RISK REGISTER (TABLE 20)

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
Risk Rating number and letter colour coding	
Black	Risk rating has remained the same since the last IM audit
Red	Risk has increased in consequence and/or likelihood since last IM audit
Green	Risk has decreased in consequence and/or likelihood since last IM audit
Grey	This risk item has been added since the last IM audit.

TABLE 20 RISK REGISTER – ORDERED BY RISK RATING

Asset	Consideration #	Consideration	Risk #	Risk Issue- 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
TSF	3.2	Geochemical	3.2.1	Acid/ metals leaching from TSF into surprise creek	L	RI	Known conduit to Surprise Creek, Capacity of tailings to go acid has been confirmed, but no quantification or timing has been determined through investigation.	Seepage recovery bores Shallow Cut-off barrier (Ineffective) Monitoring of surface water and groundwater and incoming tailings. Completion of clay cap of cell 1. Geophysical analysis undertaken in 2012	**2**	**1**	**3**	**E**	Ascertain velocity of groundwater (and acid and dissolved metals). Establish long-term oxidation rate of tailings Response to monitoring results of current tailings. Geochemistry of tailings is yet to be understood. Acid production must be considered within the Mine Closure Plan. Establish likely metal and acid concentrations in Surprise Creek, Continue to work towards the eventual recovery and reprocessing of Tailings in the TSF Cell 1 Gain a more comprehensive understanding of the geology under the TSF
TSF	3.4	Geotechnical	3.4.5	Overtopping of TSF Cells leading to embankment failure.	M	OM	Spillway under designed for flood event. Temporary bunding in spillway should not be placed as this reduces capacity of spillway to discharge during a rain event.	Inspections and GoldSim modelling undertaken annually. Increased the beached tailings at the edge of Cell 2	**1**	**2**	**3**	**E**	Increase freeboard on dam required. MRM have plans to raise this. IM has no details on this, however. Increase design storage allowance. Additional water reduction incl. Cell 1 runoff diversion from entering Cell1. Temporary bunding should not be placed in spillway. Spill rating should be confirmed. Raise dam walls on Cell 2 (This is planned by MRM) Report on effectiveness of temporary bunding at spillway and on spillway design in general. Tie assessment in to capacity of Water Management Dam

Asset	Consideration #	Consideration	Risk #	Risk Issue- 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
TSF	3.3	Leachate/seepage	3.3.1	Dry Season discharge of seepage containing salt, and metals enters Surprise Creek and causes flora die back and/ or bioaccumulation of metals in flora.	S	OM	Seepage from TSF into surprise creek.	TSF geopolymer barrier; TSF design; Seepage monitoring and recovery from sump, surface water and groundwater monitoring, plus other flora/fauna studies in Surprise creek.	**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. Subsurface cut-off drain. Undertake more extensive temporal trends monitoring Determine the gradient/survey the hydraulic flow of water from Cell2.
TSF	3.3	Leachate seepage	3.3.3	Wet Season discharge of seepage containing acid, and metals enters Surprise Creek and causes flora die back and/ or bioaccumulation of metals in flora.	M	Loc	Seepage from TSF into Surprise Creek.	TSF geopolymer barrier; TSF design; Seepage monitoring and recovery from sump, surface water and groundwater monitoring, plus other flora/fauna studies in Surprise creek.	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. Install subsurface cut-off drain. Undertake more extensive temporal trends monitoring Determine the gradient/survey the hydraulic flow of water from Cell2. Conduct flora monitoring including heavy metal analysis in early dry season at Surprise creek to evaluate effect of seepage
TSF	3.4	Geotechnical	3.4.3	Cell 2 embankment fails- Stability failure.	M	OM	Incorrect design assumptions, FoS too low, inadequate QA/QC during Construction, Poor Maintenance, Significant Storm Event, or Seismic Event. Elevated water pressure in embankment.	Daily MRM visual inspections, AWA annual inspections, Monitoring from recovery wells d/s of embankment. Changes to spigot locations means tailings now placed against embankment first	**1**	**3**	4	**H**	Design report does not match what has been constructed. Additional Piezo monitoring needs to be installed, some installed but inadequate to fully characterise phreactic surface within the embankment. Stability monitoring of embankments. Consideration of additional drainage prior to raising. Consider relocating decant location to centre to reduce risk of failure.

Asset	Consideration #	Consideration	Risk #	Risk Issue- 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
TSF	3.4	Geotechnical	3.4.4	Cell 2 Embankment failure due to scouring at toe of embankment.	M	WM	Wet season flooding - Creek at Western corner of Cell 2 scours out toe of embankment and causes collapse.	None known.	**1**	**3**	**4**	**H**	A flood route study should be conducted to assess velocities and requirement for erosion protection along embankment toe. Periodic monitoring, especially in the wet season, should be included in operating procedures.
Bing Bong dredge spoil	1.1	Drainage	1.1.1	Migration of saline/ hypersaline seepage causes local and regional vegetation die-back surrounding the dredge spoil.	M	RI	Drainage and seepage occurring into adjacent land due to seepage through pond wall. Blockage of drain to sea.	Drain to sea was established in 2009/2010, but needs repairing due to erosion. Land survey undertaken in 2010.	**2**	**3**	**5**	**H**	Monitor re-growth in areas around spoil piles for signs of stress and dieback. Ongoing monitoring and maintenance of berm walls and drains. Remove water from the spoil as quickly as possible.
TSF	3.4	Geotechnical	3.4.7	Lack of capacity to contain storm events	M	OM	Embankments and spillway not raised to sufficient height prior to upcoming and subsequent wet seasons	Dam safety audit conducted annually. Existing water balance	**2**	**3**	**5**	**H**	Detailed verification of stored volume of water on facility to be conducted (bathymetric survey and tailings beach survey). Consider downstream construction of centre embankment between Cell 1 and 2 to allow this to be raised when large pond present, with associated relocation of decant to centre embankment.

Asset	Consideration #	Consideration	Risk #	Risk Issue- 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
PACRIM and ROM	5.1	Dust emissions	5.1.1	Contamination of surface soils, vegetation, sediment with salts, heavy metals	L	RI	Spread of zinc and lead laden dust from mining operations and Pacrim yard/ROM Pad.	Dust monitoring program and dust mitigation measures including water sprays and upgrading of Pacrim conveyors. Sediment monitoring in streams and delta. Increased sprays	**3**	**2**	**5**	**H**	Dust mitigation practices should increase for the ROM/ Pacrim. Monitoring should consider long term trends to assess effectiveness of measures. Construct a spoon drain or small diversion bund over top of roadway near PACRIM to divert any contaminated runoff to the ROM Pad sump drain rather than down the road way. Implement planned air monitoring program. Implement vegetation barrier.
PACRIM and ROM	5.1	Dust emissions	5.1.2	Dust blown from ROM Pad and Pacrim yard causes loss of water and sediment quality and loss of flora/ fauna in Barney creek flood plain	M	Loc	Fugitive dust emissions from Pacrim Yard and ROM Pad.	Dust mitigation measures at mine site including Water spray trucks. Introduction of double-lipped rubber lining to sides of PACRIM conveyors.	**3**	**2**	**5**	**H**	Heavy metal concentrations have increased at some Barney Creek sediment sampling sites. Upgrading of crusher should decrease dust levels at monitoring locations in the area and thus mitigate input to the creek. Monitoring should consider long term trends to assess effectiveness of measures. Consider long term option of moving the ROM/PACRIM.

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PACRIM and ROM	5.1	Dust emissions	5.1.5	Soil contaminated with heavy metals migrates off-site due to runoff by heavy rains during the wet season and causes contamination outside of mining lease	L	OM	Spread of concentrate laden dust from mining operations and PACRIM yard/ROM Pad.	Monitoring of heavy metal concentrations in soil. Dust monitoring program. Sediment monitoring program. Upgrading of sprays and Pacrim conveyors	**3**	**2**	**5**	**H**	Increase density of soil investigations in Barney Creek for lead assessment. Assess the need to remediate areas with elevated heavy metal concentrations. Develop site specific criteria for the protection of local biota. Further efforts to redirect runoff from ROM Pad to the sump drain rather than down the roadway.
Mine site	6.1	Groundwater	6.1.1	Degradation of groundwater, surface water and land quality within the mine site	M	OM	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	**2**	**3**	**5**	**H**	Improved understanding of historic and current water geochemistry and trends, with particular focus on the TSF, OEF(s), and regional monitoring networks. Re-evaluation of current OEF materials characterisation identification and OEF design in light of proposed mine expansion. Understanding of aquifer and solute transport.
Mine site	6.1	Groundwater	6.1.3	Impact on groundwater quality and beneficial uses from hydrocarbons, reagents and other liquid products used at the Mine.	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. Improve fencing (e.g. electrify/ flood proof).	**4**	**1**	**5**	**H**	Integrity testing of fuel tanks and pipelines should be undertaken along with testing of the integrity of all bund walls and floors. Risk assessment of potential sources of spills and leaks should be conducted following the audit, and re-evaluation of management and mitigation procedures.

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River diversions	8.2	Rehabilitation	8.2.1	Slow revegetation on diversion channels.	S	WM	Large floods in wet season cause erosion and soil redistribution on unvegetated areas. Cattle and donkey damage.	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 are damaged annually by seasonal flooding).	**3**	**2**	**5**	**H**	Maintain rehabilitation efforts. Target planting efforts at soil pockets resulting from flood water redistribution of soils. Perimeter fence re-designed, installed and maintained to keep cattle out. Undertake cattle mustering. Selective planting to account for survivability of species at different levels of the bank slope. Consider conducting a trial using a range of riparian species in plots at different levels of bank slope to investigate survival. Undertake erosion assessment reports, as committed in PER.
River Diversion	8.3	Weed Management	8.3.1	Increase in spread of listed Northern Territory noxious weed species, particularly along the River Diversions.	M	RI	Historical mining and pastoral activities.Uncolonised bank and bed of river diversions.Limited cross-bank access following the wet season.	Weed Management Plan in place and carried out with liaison form NRETAS Weeds District Officer.	**3**	**2**	**5**	**H**	Continue to invest effort into weed control.Investigate possibility of cooperative weed control with pastoral properties upstream on McArthur River
Bing Bong dredge spoil	1.1	Drainage	1.1.3	Creation of acid sulfate soils by the excavation of the outer spoon drain, which causes acid leachate that affects flora/aquatic fauna.	M	Loc	Excavation of spoon drain exposes acid sulfate soils	None	**4**	**2**	**6**	**M**	Soil monitoring include ASS analysis Soil baseline survey expansion
Bing Bong dredge spoil	1.2	Geotechnical	1.2.1	Catastrophic failure of dredge pond walls leading to inundation of adjacent areas with saline material.	M	OM	Failure of pond walls/bund as a result of poor design and construction of the dam walls/bund. Overtopping and failure of walls may also occur due to high rainfall.	Infrequent inspections undertaken by Bing Bong personnel. Commitment to undertake rehabilitation trials. Culvert system installed to allow water to drain off top of dredge spoil and back out to sea. Dry cells do not pose as significant a risk of failure as wet cells. Design Check underway.	**2**	**4**	**6**	**M**	Conduct more frequent inspections of containment pond walls (it is understood that this is currently in progress). Manage future placement of dredge spoil to reduce the pressure on pond walls. Increase drainage from the containment ponds to prevent saturation of wall and piping failure. Assess suitability of existing drain pipes/culverts to cope with high rainfall events to remove water quickly. Ongoing monitoring and maintenance of culverts and drains to ensure that water in spoil ponds is flowing freely to drainage ditches.

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													Increase free-board to allow for design storm (as per design criteria) and confirm or re-assess the current rainfall and evaporation data and water balance. Implement control measures and inspections should new dredge be placed.
Bing Bong dredge spoil	1.2	Geotechnical	1.2.2	Cattle degrade the structure of the BB Dredge spoils and cause dredge material to flow from the cells	S	OM	Cattle	Inadequate fencing	**3**	**3**	**6**	**M**	Improve fencing Muster cattle out of area.
Transhipment Area	10.1	Heavy metals	10.1.1	Bioaccumulation of metals in seawater, sediments and biota in Transhipment area. Unknown sub-lethal/ chronic effects, effects on higher trophic species (including humans)	L	RI	Contamination from load out operations	Seafloor sediment heavy metal monitoring programme in Transhipment area.	**3**	**3**	**6**	**M**	Continue to monitor periodically. Further Dust mitigation required.

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Bing Bong Port	2.5	Dust migration	2.5.1	Spilling of concentrate dust during barge load out causes contamination of marine and terrestrial sediments with metals	L	Loc	Spread of zinc and lead-laden dust from ship-loading operations.	Dust monitoring programme and dust mitigation measures. Annual marine monitoring of heavy metals in seawater and sediments Fully contained conveyor system observed by IM during site inspections.	**3**	**3**	**6**	**M**	Further investigation into dust levels at Bing Bong should be undertaken. Dust Monitoring and management system requires upgrading. Plans to upgrade the dust Monitoring and management system should be implemented. Lead isotope monitoring. Potential dust monitoring on channel markers.
TSF	3.3	Leachate seepage	3.3.2	Wet Season discharge of seepage containing acid, and metals enters Surprise Creek.	S	RI	Pump back from seepage recovery system ceases during wet season due to inundation of pumps during flood events	TSF geopolymer barrier; TSF design; Seepage monitoring, surface water and groundwater monitoring, plus other flora/fauna studies in Surprise creek. Dilution during the wet season.	**5**	**1**	**6**	**M**	Subsurface drainage to be installed with submersible pumps to allow continuous pumping or seepage to be intercepted prior to leaving facility through installation of line of interception bores upstream of embankment. Continue to work towards the eventual recovery and reprocessing of Tailings in the TSF Cell 1
TSF	3.4	Geotechnical	3.4.1	Cell 1 embankment fails - spillage into Surprise Creek	M	OM	Poor Design, construction and/ or maintenance; Significant Storm Event, Seismic Event	Daily MRM visual inspections, AWA annual inspections (not complete/unsatisfactory), Monitoring from recovery wells d/s of embankment. Clay capping of Cell 1 complete. Prisms installed Groundwater wells installed	**2**	**4**	**6**	**M**	AWA 2010 report does not consider embankment stability - this should be investigated. Further piezometers should be installed embankment and tailings. Design should be investigated for adequacy.

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TSF	3.4	Geotechnical	3.4.2	Over-flow of Cell 1 due to inadequate spillway.	S	Loc	Under-designed for Flood event	Identified in AWA annual inspection that it is unclear if the spillway has been adequately designed.	**3**	**3**	**6**	**M**	IM Has not received spillway report. More detail required on spillway design. Dam safety review did not mention this issue.
TSF	3.4	Geotechnical	3.4.6	Failure of water Management Dam due to overtopping of spillway at Cell 2	M	OM	Under-design for potential flood event. Water dam undersized and/or spillway under-designed. Rating of spillway unknown (this information has not been provided to the IM).	Pumps and syphons on wall to remove water.	**2**	**4**	**6**	**M**	Verification of spillway ratings and capacity, as with item before, also tie in with overall water storage capacity.
TSF	3.4	Geotechnical	3.4.8	Excess water accumulating on facility using up available storage capacity	S	Loc	Water balance modelling done without sufficient detail, does not allow site to verify likely inflows and outflow in real time	Water balance model established but not accessible for site personnel.	**3**	**3**	**6**	**M**	Water balance model should be available to facility operators to input site data and verify available capacity. Volume of storage within WMD to be confirmed to allow emergency transfer of water to WMD if required. Re-do water balance.

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TSF	3.5	Pipeline to TSF	3.5.1	Pipeline foundations fail over river, rupturing pipe resulting in discharge of tailings into Barney Creek.	S	Loc	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 that this should also contain any leaks a result of failure of the pipeline footings.
OEF	4.1	Flora/fauna	4.1.1	Development of salt and/ or heavy metal loads in vegetation, soils and sediments causes vegetation dieback.	M	OM	Poor dust management and controls on OEF.	Dust monitoring program and dust mitigation measures such as water trucks. Annual macroinvertebrate sampling in Barney/Surprise Creeks	**3**	**3**	**6**	**M**	Regular visual inspections of vegetation condition. Continue with macroinvertebrate sampling. Annual fish monitoring in Barney and Surprise Creeks
OEF	4.2	Geotechnical	4.2.2	Erosion of capping and outer batter during wet season	S	Loc	No designed water management measures on top surface to discharge incidental rainfall	None, erosion visible at time of inspection	**4**	**2**	**6**	**M**	Surface water control to be constructed at the start of each wet season to divert water flows off waste dump without causing erosion.

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OEF	4.2	Geotechnical	4.2.4	Failure of basal encapsulation layer on slopes thereby allow water to enter the waste	L	OM	Poor placement method of placing clay on a slope, limits ability to tightly control quality. Clay layer compacted moisture condition and then left exposed which will allow desiccation of clay and potentially erosion thereby reducing effectiveness of clay liners.	Limited QA/QC testing, plus some areas covered with shallow NAF layer	**3**	**3**	**6**	**M**	Place clay on outer batter slopes in horizontal layers, 300mm vertical thickness and compact and moisture condition, with immediate placement of NAF layer outside of clay to reduce erosion and desiccation risk. Or should consider base up construction.
OEF	4.3	Geochemical	4.3.1	PAF material being placed on outer batter	L	OM	Lack of sulfur grade control. Misclassification of material due to siderite (iron carbonate) leading to an overestimation of neutralising capacity	Block model classification of PAF / NAF. Post placement sampling of grab samples.	**3**	**3**	**6**	**M**	Grade control of all blast hole samples, validation of acid neutralising capacity. Analyse for Se in OEF monitoring and seepage discharge.
OEF	4.3	Geochemical	4.3.2	Neutral drainage / metallic drainage from NAF waste placed outside of encapsulation	L	OM	Lack of detailed kinetic testing of all waste types / confirmatory testing of leach potential (NAG / Distilled Extract). No grade control testing of waste	Block model classification of PAF / NAF. Post placement sampling of grab samples.	**3**	**3**	**6**	**M**	Grade control of all blast hole samples, validation of acid neutralising capacity and leachability. Undertake lysimeter trials
Mine site	6.3	Security bonds	6.3.1	MRM Closes unexpectedly, leaving OEF, TSF, river diversions, and mine site rehabilitation unfinished.	L	RI	Inadequate planning for closure. Inadequate bond.	Revegetation has started on river diversions Monetary bond (however, may be inadequate). Progressive cap of TSF Cell 1.	**2**	**4**	**6**	**M**	OEF should be progressively rehabilitated or sealed to confirm that rehab model is appropriate and will work. Improve closure model calibration to confirm assumptions in the model. Solution to the TSF Cell 1 seepage issues must be determined. Closure plan should include contingencies for sudden closure.

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River Diversions	8.1	Fauna	8.1.1	River diversions create physical /biological barrier to fish migration.	M	RI	Loss of in-stream habitat, reduction in water quality. Altered stream flow. Increase in predation	Freshwater Sawfish Monitoring and Management Programme in place. Revegetation of diversions to increase shade in the future. Addition of large woody debris to improve fish habitat	**3**	**3**	**6**	**M**	Large woody debris - monitor and add annually. Monitor fish on Barney Creek
River Diversions	8.1	Fauna	8.1.2	Impact on riparian bird populations	M	Loc	Fragmentation of habitat, unsuitable habitat on diversions for riparian birds, reduction in water quality	Seasonal monitoring of riparian birds, targeted revegetation species used along diversions	**3**	**3**	**6**	**M**	Continue revegetation efforts. Use species mix similar to original channel. Add favoured bird habitat species such as cane grass, *Barringtonia* and *Pandanus*. Exclusion of stock from revegetation areas.
River diversions	8.2	Rehabilitation	8.2.2	Difficulty in recreating riparian vegetation communities	S	Loc	Selection of inappropriate species, cattle grazing, weed invasion, plant supply difficulties (cultivation from seed not possible, seed collection issues)	Annual vegetation monitoring, opportunistic trials, desired seed mix and density lists, large-scale tubestock planting over consecutive years, irrigation system, placement of large woody debris in diversions to reduce stream flow, weed control. Propagation of Freshwater Mangrove and Native Cane Grass in MRM plant nursery	**3**	**3**	**6**	**M**	Specific monitoring targeting preferred rehabilitation species could be useful. Increase survey sites on MR, reference plots on Barney Creek and comparison to baseline data.
River diversions	8.4	River diversion design performance	8.4.1	Flooding within mine pit	S	Loc	Very rare flood event (>500 years ARI)	Monitoring of flood warning station intranet information (with accompanying basic action plan).	**1**	**5**	**6**	**M**	Current flood warning scheme does not address/flag such an abnormal event. It is recommended the scheme be amended to address the very rare events. It is also recommended that the flood warning scheme also be improved to relate early warning river levels to imminent flooding of other potentially critical site infrastructure elements. Site Emergency Response Plan document needs to be ungraded with regard to flooding.

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River diversions	8.4	River diversion design performance	8.4.2	Erosion at toe of mine levee wall and along unplanned overland flow path from the old McArthur River Channel into diversion channel.	E	Loc	Flood flows returning to river from the direction of the remnant river channel.	Flow path conditions are examined after each wet season. After erosion experienced in 2009-2010 wet season, rock armouring works were considered to be necessary to address that scour and they were subsequently undertaken in 2010.	**3**	**3**	**6**	**M**	Following completion of the 2010 rock armouring works it was found that both the 2010/2011 and 2011/2012 wet season flows caused only minor erosion. Previous recommendation - that for long term scour protection, hydraulic flood modelling should be undertaken (through including this flow path explicitly in the HEC-RAS flood model) to quantify flow velocities over a range of flood events - remains unchanged.
River diversions	8.4	River diversion design performance	8.4.3	Ponding of water between channel and mine bund leading to increased seeapge through shallow soil zone and mobilisation of salts	L	Loc	Poor drainage design and bunds formed by mine access roads	Small diameter pipes (<100mm) pipes to allow drainage	**4**	**2**	**6**	**M**	Reshape area to ensure no ponding of water occurs.
Bing Bong dredge spoil	1.3	Dust migration	1.3.1	Development of salt loads in vegetation, soils and sediments surrounding the Dredge Spoil.	L	OM	Onshore placement of contaminated sediments from dredging.	Increased grasses help stabilise the spoil.	**4**	**3**	**7**	**M**	Additional dust monitoring sites should be installed around dredge spoil area adjacent to remnant vegetation to assess off-site impacts. Monitor vegetation surrounding the spoil. Commencement of revegetation trials.
Bing Bong Port	2.1	Groundwater	2.1.1	Impact on groundwater quality and beneficial uses, from hydrocarbons, reagents and other liquid products used or stored at Bing Bong Port.	M	Loc	Vehicle movement over sub-surface fuel and liquid pipelines, corrosion of infrastructure, accidents and spills.	Hydrocarbon Audit undertaken in 2011. Groundwater and surface water monitoring. Inspection procedures of pipelines and infrastructure. Incident report forms Groundwater bores have been installed at BB, analysis for TPH, BTEX should be conducted annually to determine presence of dissolved hydrocarbons in groundwater.	**4**	**3**	**7**	**M**	Implement findings of Hydrocarbon Audit. If infrastructure older than 10 years, a soil investigation should be undertaken around the infrastructure to determine any contamination.

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Bing Bong Port	2.3	Flora	2.3.1	Loss of seagrass outside the channel which may affect seagrass dependent communities or populations (e.g. dugongs).	S	Loc	Loss of seagrass from dredging operations, turbidity from regular Aburri passage, and sedimentation cyclones or severe weather.	Annual seagrass monitoring program indicated increasing seagrass distribution in 2011.	**4**	**3**	7	**M**	Continue with current monitoring. Make clear distinctions between channel and adjacent areas in terms of seagrass loss. Establish control site as recommended in Seagrass Monitoring Report. A post disturbance survey should be conducted if a large disturbance event impacts seagrass communities. This would distinguish natural from anthropogenic disturbances. Incorporate data from long establish national park on sir Edward Pellew Islands, Barranyi national park, and newly declared Indigenous Protected Area, Yanyuwa IPA.
Bing Bong Port	2.4	Fauna	2.4.2	Bioaccumulation of metals in seagrass and molluscs in vicinity of load out facility. Effects further along food chain. Unknown sub-lethal/ chronic effects	M	Loc	Dust migration, Spillage of ore during barge loadout.	Annual marine monitoring programme. Dust monitoring programme and dust mitigation measures. Closed barge loading procedures observed by the Independent Monitor in May 2011.	**3**	**4**	7	**M**	Monitor elevated levels of metals from ore derived sources. Analyse and report on samples from Barramundi tissue and mud crabs from SEPI/MR estuary area.
Bing Bong Port	2.5	Dust migration	2.5.2	Spilling of concentrate dust during trans-shipment operations causes contamination of marine sediments with metals	L	OM	Concentrate fallout during trans-shipment operations	Monitoring of marine sediments in trans-shipment area. Aburri barge is periodically washed down and material collected in a sump.	**3**	**4**	7	**M**	Continue assessment of sediments in the trans-shipment area. Lead isotope monitoring.

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OEF	4.2	Geotechnical	4.2.3	Failure of basal encapsulation layer to prevent seepage.	L	OM	Clay layer compacted moisture condition and then left exposed which will allow desiccation of clay and potentially erosion thereby reducing effectiveness of clay liners.	Limited QA/QC testing	**3**	**4**	**7**	**M**	Only prepare a small area in front of PAF waste placement or paddock dump a layer of PAF waste over completed clay layer to reduce evaporation losses from clay and erosion risk. Or should consider base up construction.
OEF	4.2	Geotechnical	4.2.5	Formation of preferential pathways for oxygen to enter the dump	L	OM	End tipping waste from high tip head, leads to segregation of PAF waste with coarse material at base of tip face.	None	**4**	**3**	**7**	**M**	Place all PAF waste as paddock dumps or reduce the tip head height down to 5m to reduce segregation of PAF waste. Or should consider base up construction.
OEF	4.3	Geochemical	4.3.3	Increased rates of oxidation of placed waste and increased metal, acid and salt loads in seepage	S	Loc	No capping placed over top of completed waste dumps	None, except truck compaction of top surface, however waste is competent rock and therefore will do little to limit infiltration.	**4**	**3**	**7**	**M**	Top capping layer should be placed immediately on completion of waste dump area and preferably interim caps should be placed prior to each wet season.

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PACRIM and ROM	5.1	Dust emissions	5.1.4	Bioaccumulation of metals in flora and fauna within or around river diversions. Intake of heavy metals from mine dust on vegetation may accumulate in cattle and affect clean green status of product for NT	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, vegetation monitoring, monitoring of heavy metals in fish, macroinvertebrate monitoring, water monitoring	**3**	**4**	**7**	**M**	Dust mitigation measures should be reassessed to increase frequency of water spraying at Rom pad and Pacrim yard, for example. Test bioaccumulation in Flora and Fauna. Introduce fish monitoring in Barney Creek. Undertake lead isotope studies of suspended sediments in the McArthur River delta area. Heavy metal testing of molluscs. Investigate heavy metal levels in vegetation within diversions. Desk top assessment to determine potential impact on cattle economy of pastoral properties of bio-accumulation of heavy metals in livestock.
Mine site	6.4	Waste oil and fuel storage containment	6.4.1	Spill of hydrocarbons from waste oil storage area, refuelling lines or tanks for soil across the site.	M	P	Existing bunding damaged. No self bunded pallets, No sump, failure of bunding, fuel likes or tanks.	Hydrocarbon infrastructure audit undertaken in 2011 Operational period with subsequent action items.	**4**	**3**	**7**	**M**	Remediation Action Plan for Hydrocarbon remediation for sludges and spills. Consider a Bioremediation facility. Improved strategy for hydrocarbon management
Mine Site and Bing Bong	7.1	Environmental monitoring programs	7.1.1	Incomplete QA/QC procedures result in errors in datasets and thus potentially wrong management actions	S	WM	Insufficient QA/QC procedures in environmental monitoring programs	Limited QA/QC procedures are currently being undertaken	**4**	**3**	**7**	**M**	Ensure QA/QC procedures meet environmental industry standards and are discussed, interpreted and acted upon.

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Mine Site and Bing Bong	7.1	Soil Monitoring	7.1.3	Lack of appropriate soil monitoring may mean contamination of particular areas is not noticed	L	WM	Insufficient spatial density and poor optimisation of analytes.	Limited soil sampling program and limited discussion and optimisation of laboratory analytes.	4	3	7	M	Upgrade soil monitoring program to include areas of sampling not currently covered by the current monitoring program.
Sir Edward Pellew Islands (SEPI) and McArthur River Estuary	9.1	Heavy metals	9.1.1	Bioaccumulation of metals in sediments and biota in vicinity of SEPI and MR estuary. Unknown sub-lethal/ chronic effects, effects on higher trophic species (including humans)	L	RI	Contamination from McArthur River upstream mine activities or Bing Bong Port operations.	Annual mollusc (gastropods and bivalves), seagrass and sediment monitoring program.	**3**	**4**	**7**	**M**	Analyse and report on samples from Barramundi tissue and mud crabs from SEPI/MR estuary area. Continue monitoring, but include monitoring of suspended sediments for lead isotope analysis.
Bing Bong dredge spoil	1.4	Revegetation	1.4.1	Failure of revegetation on dredge spoil causes habitat loss or alteration and dust potential.	S	P	Spoil material unsuitable for vegetation establishment. Revegetation trial cancellation by student. Inappropriate or inadequate research. Severe weather. Ongoing dredging.	Previous monitoring by orthophoto mapping and ground truthing of vegetation. CDU PhD student was to commence revegetation trials on a section of the spoil. Area of dredge spoil ponds reseeded with grasses in 2011.	**4**	**4**	**8**	**L**	Continue to monitor surrounding vegetation by aerial mapping and visual inspections. Conduct rapid, ground surveys of vegetation annually. Continue with rehabilitation of dredge spoils - utilise landscaping of cells to promote veg growth despite future dredge plans. Student has failed to start the trials at CDU, so MRM should contract the work to another party.
Bing Bong dredge spoil	1.5	Weeds	1.5.1	Habitat alteration due to weed infestations on dredge spoil/rehabilitated areas.	M	RI	Insufficient weed management.	Weed inspections by District Officer and MRM staff. Parkinsonia biological control trials ceased and Parkinsonia exterminated Control of weeds as per the Weed Management Plan.	**4**	**4**	**8**	**L**	Regular monitoring and control of weeds.

Asset	Consideration #	Consideration	Risk #	Risk Issue- 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 Port	2.2	Surface water	2.2.1	Overflow of Bing Bong surface runoff pond (BBSRP) containing metals and acid contaminates surrounding environment .	M	Loc	High rainfall/ storm event, or failure to clean out sediment from pond. Mismanagement of water volumes	3 adjacent surface runoff containment ponds. Roof runoff capture system installed in 2011 removes 1.8Ha of catchment from system (with separate first flush system) BBSRP maintenance program. Annual water balance modelling undertaken. Evaporation of pond water through use of pond water as dust suppression across site. Annual marine heavy metal monitoring. Trucks transporting water to TSF (as previously required)	4	4	8	L	All three runoff ponds should be cleaned out and emptied as far as practicable prior to the wet season. Design report associated with the two new runoff ponds to be reviewed by the Independent Monitor. Confirmation that Goldsim modelling will be undertaken annually
Bing Bong Port	2.4	Fauna	2.4.1	Bing Bong Port operations negatively impact important migratory bird populations. Lethal or chronic sub-lethal effects to migratory birds.	L	RI	Heavy metal bioaccumulation in food sources of migratory birds caused by dust migration or concentrate spillage from Bing Bong Port operations.	Monitoring of heavy metals in sediments and biota. Yearly Migratory Bird Surveys. Dust monitoring and control measures implemented.	3	5	8	L	Further reduce dust emissions from Bing Bong Port. e.g. by enclosing concentrate shed. Continue monitoring migratory bird populations.
Bing Bong Port	2.5	Dust migration	2.5.3	Dust blown from Bing Bong Port facility causes loss of water and sediment quality and loss of flora/ fauna in St Edward Pellew Islands.	L	Loc	Fugitive dust emissions from concentrate shed and during loading of vessels.	Monitoring of sediment and seawater within the estuary and St Edward Pellew Islands. Improved concentrate loading practices.	4	4	8	L	Dust mitigation measures should be increased at Bing Bong. Ventilation and vacuum system to be implemented as soon as practicable within the concentrate shed. Street sweeper should be employed. Monitoring should consider long term trends to assess effectiveness of measures. Further dust monitoring on channel markers.

Asset	Consideration #	Consideration	Risk #	Risk Issue- 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 Port	2.5	Dust migration	2.5.4	Dust migration from Bing Bong storage shed cause heavy metal contamination of marine sediments and seawater in Bing Bong Port, which may potentially affect local biota	L	Loc	Concentrate dust from Bing Bong concentrate storage shed transported by winds and runoff	Dust suppression sprays in operation across the site. Annual marine monitoring of heavy metals in sediments and monthly monitoring of seawater. DGT monitoring for assessing labile metal concentrations in seawater.	4	4	8	L	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. Undertake dust audit. Implement improvements to the Bing Bong concentrate storage shed so that roller doors can remain shut.
TSF	3.5	Pipeline to TSF	3.5.2	Pipeline on ramp to TSF failure - discharge to surprise creek.	S	Loc	Pipeline not bunded.	Visual inspections.	**4**	4	8	L	Bund pipeline or secondary containment needs to be installed or constructed.
TSF	3.6	Rehabilitation	3.6.1	Stockpiled topsoil not available for rehabilitation of tailings dam or waste dumps.	L	P	Topsoil not used progressively, not labelled or mapped, used for wrong purpose or buried.	2010/11 MMP describes some areas where topsoil will be stripped from and areas that will require topsoil in the future. Topsoil location mapping	**4**	**4**	8	**L**	Signs on topsoil stockpiles in the field.
PACRIM and ROM	5.2	Structural Design	5.2.3	Undercutting of the base of the ROM Pad within the outer spoon drain sump causes slumping of ROM Pad wall into the sump.	S	Loc	Toe of the drainage channel/sump is being undercut by rising and falling water levels	None at the moment	4	4	8	L	Undercutting of the base of the ROM Pad within the outer spoon drain sump causes slumping of ROM Pad wall into the sump.

Asset	Consideration #	Consideration	Risk #	Risk Issue- 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
Mine site	6.1	Groundwater	6.1.2	Complete depressurisation of aquifers, reduction in yield and water quality affecting regional groundwater and groundwater dependent ecosystems.	M	OM	Excessive drawdown of aquifers due to dewatering for mine pit and water supply.	Groundwater monitoring. Evaluation of groundwater model. Produce hydrographs of all borefield bores, including pressure transducer placement in select bores and comparison of pressure data to rainfall.	**3**	**5**	**8**	**L**	Calibration of the groundwater modelling undertaken in 2006 (EIS) should be undertaken annually and the model re-run every 3-5 years.
Mine site	6.2	Water extraction from the McArthur River.	6.2.1	Water extraction impacts aquatic flora and fauna due to lack of water availability.	E	OM	Over-extraction reduces dry season flows in river.	Pump flow meter monitoring system. Annual aquatic fauna surveys.	**4**	**4**	**8**	**L**	2010 IM Audit report recommended improvements in the recording of extracted flows and in 2011 MRM staff advised that changes were proposed. It is unclear if all those changes are in place. It is important that Upstream River flow data be recorded to demonstrate adherence to the extraction licence conditions.

Asset	Consideration #	Consideration	Risk #	Risk Issue- 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
Mine Site and Bing Bong	7.1	Environmental monitoring programs	7.1.2	Inadequate analysis, discussion of monitoring results causes environmental issues to be overlooked or remain unmitigated.	M	WM	Inadequate reporting. Lack of human resources or certain technical skills in-house.	Independent Monitor Program Department of Mines and Energy check monitoring	**4**	**4**	**8**	**L**	Ensure complete scientific and comprehensive reporting is undertaken for each monitoring program. Analyse and discuss trends in data, sources of contamination and mitigation measures for preventing environmental harm. Contract out reporting or data analysis to suitably qualified external consultants if the technical expertise or human resources are not available in-house. Hydrogeology and hydrogeochemistry should be discussed together.
River diversions	8.4	River diversion design performance	8.4.4	Sudden and significant flood-induced channel bank erosion/collapse leads to unexpected increase in flood level.	S	Loc	Flood event.	Taking of photographs - post wet season - along both banks at 250 metre spacing.	**4**	**4**	**8**	**L**	Review of evidence of erosion shown in photograph series. Recommended utilisation of aerial photographs and annual aerial survey plans to assess on-going changes in bank and bed levels which would then potentially trigger the need for additional bank protection works.
Sir Edward Pellew Islands, McArthur River and Bing Bong Port	9.2	Vibrio bacteria	9.2.1	Mining activities cause vibrio bacterial infection of local people.	E	RI	Unknown. Possibly contamination by sewage.	Vibrio monitoring.	**3**	**5**	**8**	**L**	The study should be repeated in the wet season in order to determine whether there are any changes in the Vibrio diversity associated with the substantially different environmental conditions of the wet season. Investigate possibility of a PhD student to take on project.

Asset	Consideration #	Consideration	Risk #	Risk Issue- 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
TSF	3.1	Dust migration	3.1.1	Development of salt and/or heavy metal loads in vegetation, soils and sediments surrounding the TSF.	M	Loc	Poor dust management and control on Cell 1 and Cell 2.	Dust monitoring programme and dust mitigation measures proposed and actual rehabilitation trials (TSF Cell 1). Cell 1 now capped. Vegetation of Cell 1 and reshaping of eroded clay cover to ensure that exposed tailings are covered.	4	5	9	L	Continue to maintain Cell 1 clay cover in good condition. Continue temporary revegetation of Cell 1 Cover. Maintain regular inspections of cover integrity.
TSF	3.1	Dust migration	3.1.2	Dust contamination of Surprise creek causes loss of flora/ fauna or bioaccumulation of metals within tissues. Dust migrates downstream.	M	WM	Dust blown from TSF towards Surprise Creek.	Clay cap of Cell 1 Monitoring of invertebrates in Surprise Creek Water quality and Chemical monitoring of surface water.	4	5	9	L	Establishment of vegetation cover on Cell 1.
PACRIM and ROM	5.1	Dust emissions	5.1.3	Dust blown from ROM Pad and Pacrim yard causes loss of water and sediment quality and loss of flora/ fauna in The McArthur River	L	Loc	Fugitive dust emissions from Pacrim Yard and ROM Pad.	Dust mitigation measures at mine site including Water spray trucks.Introduction of double-lipped rubber lining to sides of Pacrim conveyors.	4	5	9	L	Dust mitigation measures should be increased around ROM Pad/Pacrim yard. Upgrading of crusher should decrease dust levels at monitoring locations in the area and thus mitigate input to the creek. Monitoring should consider long term trends to assess effectiveness of measures. Consider long term option of moving the ROM/PACRIM

Asset	Consideration #	Consideration	Risk #	Risk Issue- 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
PACRIM and ROM	5.2	Structural Design	5.2.1	Erosion of bund wall causes release of contaminated water into Barney Creek	S	Loc	Abnormal storm event	Regular inspections of condition	**4**	**5**	**9**	**L**	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.
PACRIM and ROM	5.2	Structural Design	5.2.2	Failure of pump within ROM Pad sump area during heavy rainfall event causes sump water to flow towards Barney Creek.	S	Loc	Abnormal storm event and pump or power failure.	Regular inspections have been carried out since February 2009.	**5**	**5**	**10**	**L**	It is anticipated that the storage within the ROM would not overtop rapidly and that there would be enough time to deploy a substitute pump in case of failure. However, analysis of the storage size against design rainfall events should be undertaken to give an estimate of the duration the ROM storage could run for without a pump, before overtopping occurs.

APPENDIX B GAP ANALYSIS FLOW CHART AND TABLE

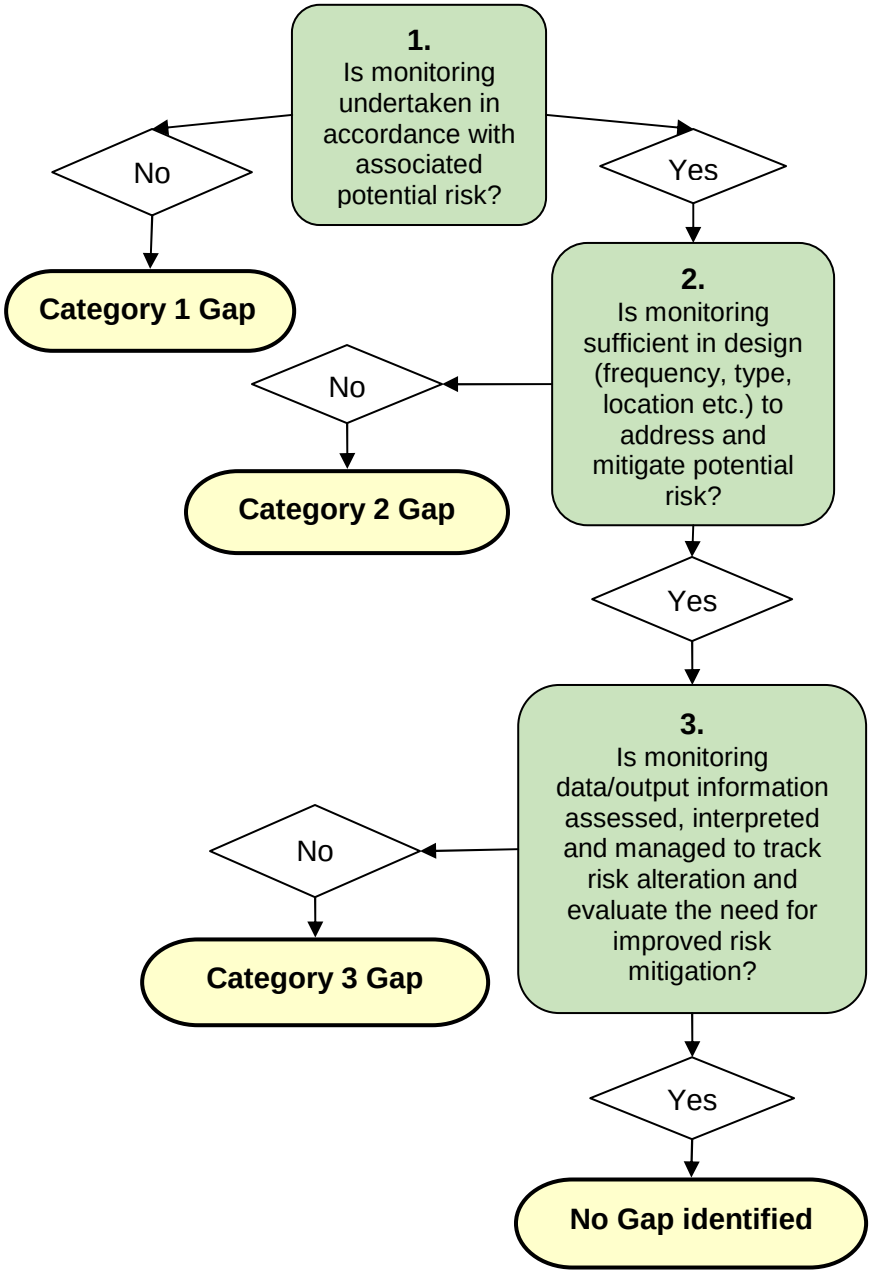

Figure 38 Independent Monitor Gap Analysis Process Flowchart.

TABLE 21 GAP ANALYSIS REGISTER FOR THE 2011 OPERATIONAL PERIOD

No.	Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
			1	2	3	
Mine Site						
1	**Waste rock**	Inadequate geochemical analysis and confirmation testing of waste rock and tailings.		**x**		The Independent Monitor is concerned that the type of visual classification undertaken to identify NAF and PAF may not be adequate. Site discussions with the Mining Manager indicate that an understanding of the current waste characteristic contents of the OEF is not well understood, compared with the original OEF design. An waste rock block model should be constructed and independently reviewed.
2	**Tailings geochemistry**	Acid/base accounting .		**x**		The Independent Monitor advises that results be reviewed annually in terms of initial projections of tailings geochemistry, acid production and long term weathering effects.
3	**Tailings Geochemistry**	Inadequate IMACs section 6.4 Notification follow-up		**x**		The Independent Monitor advises that the seepage prediction investigation work was not appropriately targeted to ensure a valid assessment of the time prediction for when the system will go acid, and travel time to Surprise Creek.
4	**Civil works**	Inadequate monitoring of diversion channel bank erosion/slumping. This has been done but interpretation still needs to be carried out.			**x**	Photograph now being collected on both side of channel. It is further recommended that Lidar survey is collected over the diversion channel and overlain on previous data to determine erosion and deposition locations.
5	**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. It is noted that a draft report has very recently been produced and should be reviewed in next audit period.
6	**Civil works**	Inadequate clay lining materials testing / compaction test results for OEF. (This has been done, however, reporting and interpretation is not clear in terms of corrective measures)			**x**	Testing has been conducted of the clay liner but no indication of when testing was conducted in relation to covering of clay to prevent desiccation. No reconciliation of rate of testing i.e. one test per 5000m3 of material placed. Also no comprehensive construction report only raw results, a construction report giving details of when, where and what was tested and the pass / fail rate should be conducted annually.

No.	Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
7	**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. (not seen in Monthly Reports)	x			Without this information it is not possible to verify that the OEF foundation has been correctly constructed.
8	**Civil works**	No information is available on the current stability of the Cell 1 or Cell 2 embankments. (Is currently in progress through in-situ testing (IGS), needs to be summarised in report and reviewed by independent reviewer)	x			A 'Dam Safety Review' for the TSF (including WMD) has been conducted but the major item to be addressed (embankment stability) has not been addressed.
9	**Civil works**	Incomplete/not provided information on the design and construction of the water management dam (WMD) at the TSF. (Still no design and stability analyses included)	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.
10	**Civil works**	Apparent lack of a Dam Emergency Response Plan for the TSF.	x			No Dam Emergency Response plan or operating manual has been sited by IM
11	**Civil works**	Lack of regular embankment quantified monitoring system for the TSF. Much improved, recommend independent reviewer to assess required quantity of monitoring points as well as quality of data.	x			Limited piezometers have been installed in the inactive cell 1, no piezometers in the active cell (Cell 2). Survey prisms have been installed but no monitoring data has been seen by IM, it is recommended that these are monitored at least every six months and prior to and immediately after any construction works. Should be surveyed once a year or monthly.
12	**Flora/fauna**	Vegetation monitoring along the diversions - insufficient vegetation monitoring sites on the MR diversion, analogue sites for Barney Creek and comparison to baseline data.		x		More sites along the McArthur River Diversion, more comparison to baseline data and more suitable reference sites, particularly Barney Creek.
13	**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.

No.	Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
14	**Surface water**	Fluvial sediment chemistry - no discussion on results for major cations, EC, PSA or fine fraction (i.e. >63 µm) heavy metals in the WMP. This issue has been flagged in previous audits.		x		The Independent Monitor recommends that chemical and physical monitoring and interpretation of fluvial sediment data be included in subsequent Water Management Plans.
15	**Rehabilitation**	Lack of fencing maintenance to keep cattle from destroying revegetation along river diversions.		x		The IM has viewed evidence of MRM's planned re-fencing activities to minimise flood damage and improve access for repairs. A portion of fencing was relocated to higher ground in 2011; reassess location of remaining fence along diversion. Investigate the use of plain wire on fencing instead of barbed wire as barbs cause debris to get caught in fence during periods of high flood resulting in the fence being weighed down and more easily dislodged.
16	**Surface water**	Apparent discrepancies in water levels/flow values recorded at upstream and downstream McArthur River gauges (and other gauges)			x	While it is recognised that investigations are continuing regarding the accuracy of water level recordings and generation of and/or amendments to individual rating tables, it is important that the investigations are thorough and subsequent recommendations for improvements implemented. It is recognised that the Barney Creek River Station has been moved to the highway bridge to avoid backwater impact issues associated with the McArthur River being in flood.
17	**Surface water**	IM has reported apparent errors in flows derived at either or both Upstream and Downstream McArthur River stations. Any significant errors in the lower end of the rating table for the Upstream McArthur River river station could result in incorrect triggering of opportunity to extract river flows relative to compliance with Government approval for water extraction.		x		It is acknowledged that the river water level and flow details for the various river stations are currently being reviewed.
18	**Surface water**	Inadequate reviews of condition of/performance of sediment control structures.			x	While a new reporting system commenced in late 2010 there are inadequacies in wet season monitoring and in reporting of maintenance task completions.

No.	Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
19	**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 understood and urgently reported. While it is understood that currently there is work being done to update the accuracy of the various river stations it is unclear if work at the Early Flood Warning station will be sufficient to address the current lack of understanding of an impending very large flood.
20	**Dust/ air quality**	No continuous dust monitoring system currently in place for Total suspended particles (TSP).	**x**			Lack of continuous particulate monitoring does not allow the determination of volume of dust concentrations, nor allows correlating dust levels to wind direction or particular events. This has been addressed at the TSF and is expected to be implemented at the PACRIM in 2013.
21	**Soil**	Insufficient number of sampling locations, which are also limited to dust locations.		**x**		The number of soil samples is currently considered to be insufficient considering the large area of the mining leases. It is recommended that additional soil monitoring locations be included in the soil monitoring program to increase the sample size. As soil is monitored at the dust monitoring locations, increasing the number of dust monitoring locations will also increase the number of soil monitoring locations. We recommend that a complete soil landscape study of the mine leases be conducted in the next 2-5 years to update the study already undertaken as part of the EIS for the Mine's expansion in 2007.
22	**Soil**	Lack of site specific trigger levels	**x**			No site specific trigger criteria have been derived for the mine site. This is proposed in MRM's own current Preliminary Mine Closure Plan (March 2008) although it has been noted that MRM now default to the more conservative NEPM Environmental (or Ecological) Investigation Levels (EILs) which provide a more relevant (and conservative) criteria than HILs
23	**Sediments**	Lack of monitoring outside of swing basin	**x**			Samples at either side of the transects (outside the swing basin) should be collected and analysed to assess the lateral extent of heavy metal impacts. In addition, transect samples already being collected as part of the marine monitoring program should be analysed individually and not composited. This recommendation has been made previously and it is understood that MRM plan to rectify this issue.

No.	Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
24	**Dust, Soil and Sediments**	Background heavy metal concentrations have not been determined.			X	Determine background heavy metal levels as recommended in the Independent Monitor Technical Review in order to assess potential mining impacts and current conditions, and improve development of sit-specific criteria. It is noted that control sites have been established by the macrointebrate assessment and data has been collected that can potentially be used as background heavy metal concentrations.
25	**Fauna**	No monitoring of fish in Barney Creek	x			Incorporate sites on site creek into the current fish monitoring program conducted on McArthur River. This is necessary to determine health of the creek and fish use of Barney Creek diversion
26	**Fauna**	Insufficient frequency of fish monitoring on Surprise and Little Barney Creeks		x		Fish survey conducted as a singular occurrence survey in 2011 in response to concerns of negative effects on aquatic fauna from tailings seepage. Should be conducted bi-annually to determine changes in fish diversity/abundance and presence of metals in fish. Trends will aid in detection of increased/decreased seepage and effects on aquatic life over time.
27	**Flora**	Lack of synergistic weed management with upstream pastoral properties		x		Work in conjunction with pastoral properties upstream on the McArthur river on weed control, with the aim of decreasing likelihood of McArthur river diversion being repopulated with weeds from sources outside of the mine boundary. Will save costs in weed control and promote community relations.
28	**Flora**	Lack of monitoring of flora in Surprise Creek to evaluate effect of TSF seepage	x			Monitoring of abundance of vegetation, composition and heavy metals in flora is necessary and would provide valuable information of the effect of tailings seepage on Surprise Creek's vegetation community and help steer mitigation measures
29	**Flora**	Lack of monitoring of heavy metals in flora in McArthur river and Barney Creek	x			Monitoring of bioaccumulation of metals in flora to ensure dust emissions from mining operations and disturbance of channels is not negatively impacting flora in Barney Creek and McArthur River
30	**Fauna**	No results of Heavy metal analysis provided in Fish monitoring report			x	fish monitoring report that heavy metal analysis on biota will be conducted. Samples taken during May/June survey but no results or discussion provided.

No.	Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
	Bing Bong Port and McArthur River Delta					
31	**Civil works**	There is no documentation regarding design/construction or subsequent geotechnical monitoring of the Bing Bong Spoil Facility. (Is in progress, needs to be concluded in report which will be reviewed)	**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.
32	**Flora**	Monitoring of vegetation outside dredge spoil has not been carried out in the reporting period.	**x**			Aerial photographs are available but have not been interpreted in a report. Aerial photographs to include surrounding vegetation and mangroves. Ground survey to include reference sites.
33	**Flora**	Trials for dredge spoil rehabilitation.	**x**			Proposal sighted, but has not been undertaken as yet. CDU student failed to commence study.
34	**Fluvial Sediments**	No monitoring of sediments within the McArthur River Delta		**x**		McArthur River Delta sediments should be included in the fluvial sediment monitoring program. Suspended sediments have not been reanalysed and monitored for lead isotopes to compare with the settled sediments on the delta floor.
35	**Marine Monitoring**	Physicochemical parameter monitoring at Bing Bong and Sir Edward Pellew Islands		**x**		Each sampling site is only sampled once without consideration to tides, currents, weather, daytime and other variables. This only provides a snapshot of the situation at sampling time. The data is not adequate for intended purposes. A sampling series should be conducted that provides a more useful data range.
36	**Marine physico-chemical qualities**	Data gathering does not produce comparable data to allow interpretation			**x**	Devise data gathering method, such as sampling from a particular site repeatedly over an extended time period to allow variability in data to be determined.
37	**Fauna**	Is there a need to look at impact of the mining and shipping operation on "clean green" quality of cattle?	**x**			A simple desk top assessment of the impact of mining and trans shipment ore on potential cattle intake of heavy metals, etc may show this is not an issue, but it would prevent questions being asked.
38	**Flora**	No control sites included in seagrass survey at Bing Bong		**x**		Add control sites to current survey design, located a sufficient distance away from influence of Bing Bong port to help determine if results are as a result of MRM
39	**Flora/Fauna**	Lack of documentation regarding current practices involving ballast water from ship at Bing Bong e.g.. ballast water source, dumping location	**x**			Desktop assessment of requirements and current practices with results documented, possibly in WMP if not stand-alone document

No.	Monitoring area	Monitoring Gap	Gap Category			Recommendations/ Comments
40	**Heavy metals**	No report provided for Annual marine monitoring in Transhipment area			**x**	Heavy metal analysis of biota, sediments and seawater may provide important data on the presence of metal resulting from load out operations. This could not be reviewed as report was not supplied.
	Total		**17**	**15**	**8**	

APPENDIX C REVIEW OF MMP COMMITMENTS 2010/2011 MMP

TABLE 22 2010/2011 MMP COMMITMENTS RELEVANT TO ENVIRONMENTAL PERFORMANCE

MMP Commitment Number	MMP Section reference	Commitment	IM Compliance rating	IM Comment
4	1.5	*An additional reporting requirement introduced in 2009 is the submission and approval of a Sustainable Development Water Management Plan which outlines infrastructure, controls and monitoring based around all operational facets of water for the site and Bing Bong.*	Compliance	The Independent Monitor is pleased the see an increased detail of reporting presented each year within the SD WMP.
6	1.7	*Annual MMP's will therefore be submitted by the 1st of November annually for the reporting period 1st November to 30th October each subsequent year.*	Compliance	2010/2011 MMP and 2011/2012 MMP have been provided for review this Audit. The IM is pleased to see an increase in the level and detail of reporting in the MMP over the past 5 years of monitoring.
7	2.1.5	*A survey of freshwater fishes particularly targeting the Freshwater Sawfish (P. microdon) was undertaken in May 2006 in the McArthur River to provide additional data on the distribution and abundance of this species. This led to a Freshwater sawfish Monitoring and Management Plan completed in March 2007 and was followed by another Fish fauna survey completed in June 2007. During 2008, 2009 and 2010 fish surveys were also conducted and a summary of these have been included in the WMP submitted in August 2010.*	Compliance	Freshwater Sawfish Monitoring report reviewed.
8	2.1.6	*On an ongoing basis the only species from the above table that undergoes specific monitoring include the Freshwater Sawfish, Purple Crowned Fairy Wren and the White-browed Robin.*	Compliance	Freshwater Sawfish Monitoring report and Riparian bird Survey reports reviewed by the IM.
9	2.2.1	*Cattle have been excluded from the mining and processing areas by the construction of a 17 kilometre fence line. During every wet season this perimeter fence line is damaged as a result of floods.*	Partial Compliance	MRM have made efforts to exclude cattle from the mine areas, however flood damage still occurs each year and cattle are permitted access to the mine site and rehabilitation areas. Cattle and donkeys were observed on site during the IM site inspection in late May 2012.
10	2.2.3	*For normal operations, if any employee (or contractor) needs to undertake any ground disturbing activity, they must obtain approval from both MRM's Community Relations Department and Environmental Department, in order to ensure that no inadvertent damage is caused to any features of cultural heritage or environmental significance. This is conducted through the Permit to Clear system.*	Not verified	Not verified this audit.

MMP Commitment Number	MMP Section reference	Commitment	IM Compliance rating	IM Comment
12	3.1	*Every year McArthur River Mining revises its Sustainable Development (SD) Strategy, Policy and Annual SD Plan. The SD Annual Plan outlines objectives and targets for the next operational year.*	Compliance	SD Policy: Dated July 2011 SD Strategy: Dated July 2011 SD Plan: Dated 1 November 2011
13	3.3.2	*Continue to present HSEC awareness topics to all Administration Department personnel through monthly HSEC meetings and departmental toolbox meetings.*	Not verified	Not verified this audit
14	3.3.2	*Achieve 1% reduction in energy intensity (per tonne of final product/ ore milled) over 2007 performance by 2012.*	Not verified	Not verified this audit
16	3.3.2	*Set long-term reduction targets (3 years) for GHG direct emissions intensity (per tonne of final product/ ore milled) over 2010 performance.*	Compliance	Air Quality and Greenhouse Gas Assessment for the McArthur River Mine Phase 3 Development Project. Dated Jan 2012.
17	3.3.2	*No loss of IUCN red list of endangered species on the leases of managed operations, and no loss of species identified as under threat by NT and Commonwealth Government.*	Compliance	The IM is not aware of any species lost during the Audit period.
19	3.3.2	*Investigate and start implementation of biodiversity offset.*	Compliance	The meaning of this commitment is unclear, although it is assumed to relate to the establishment of riparian habitat for Carpentarian grass-wren (*Amytornis dorotheae*); Purple-crowned fairy-wren (*Malurus coronatus coronatus*), and (*Malurus coronatus macgillivrayi*) and the White-browed robin *(Poecilodyras superciliosa).* The IM has inspected attempts at the establishment of such habitat.
21	3.3.2	*Review and update waste minimisation plans, including waste to landfill reduction targets, set targets based on current use.*	Not verified	According to the 2011/2012, MRM state that this commitment has been met. However the IM has reviewed the Waste Management Plan 2011, which does not identify waste reduction targets for wastes going to landfill.
22	3.3.2	*Update Waste Management Plan annually.*	Compliance	Waste Management Plan reviewed, Dated March 2011
24	3.3.2	*Continue to monitor aspects of flora and fauna in line with both N.T. and Commonwealth legislative requirements.*	Compliance	The IM has reviewed all fauna and flora monitoring reports
26	3.3.2	*Ensure the Commonwealth Environment Report is submitted annually by the 30th of October.*	Not verified	The Commonwealth Environmental Report was not provided as part of the Data Package to the IM this audit.

MMP Commitment Number	MMP Section reference	Commitment	IM Compliance rating	IM Comment
27	3.3.2	*Implement programmes in conjunction with Charles Darwin University on aspects of acid mine drainage and metal resistant microbes.*	Compliance	These projects are listed on the CDU website as having been completed.
28	3.3.2	*Ensure timely implementation of all monitoring requirements for environment.*	Compliance	Through this year's audit, the IM has not noted any significant time delays in the implementation of environmental monitoring program at MRM.
29	3.3.2	*Continue the assessment of rehabilitation establishment to determine rehabilitation success and to identify any mitigation strategies that may be required.*	Compliance	Annual 2011 Rechannel Rehabilitation Plan, Annual 2011 Weed Management Plan
30	3.3.2	*Where available, to conduct further rehabilitation activities in the McArthur River Channel and Barney Creek.*	Not Verified	Not verified this audit.
31	3.3.2	*Stock nursery with required plants.*	Compliance	Nursery inspected during 2011 and 2012 IM site inspections. MRM Seed Storage Register excel file reviewed.
32	3.3.2	*In addition to the rehabilitation of diversions, where available, to proceed with seeding on topsoil stockpiles, decommissioned workshop areas and roads, go lines and other distributed areas to prevent erosion and promote soil health.*	Partial compliance	Area behind PACRIM ROM loader ramp planted with seedlings and area inside of Mine levee wall reseeded. It is unknown if any other areas such as topsoil stockpile have been reseeded. The IM believes that further efforts could be concentrated on rehabilitation of disturbed areas other than the diversions.
33	3.3.2	*To implement further rehabilitation strategies for Tailings Storage Facility (TSF) Cell 1.*	Partial compliance	MRM has a rehabilitation strategy in place for Cell 1, which at this stage includes the maintenance of a clay cover for dust suppression, with some plants temporarily established on the surface. As such, maintenance of the cap is an appropriate remediation strategy at this stage, as MRM have advised their intention to potentially reprocess tailings within Cell 1 in future.
34	3.3.2	*Continue rehabilitation trials on the Bing Bong dredge spoil.*	Partial compliance	The IM Is aware that MRM has not
35	3.3.2	*No environmental fines, penalties or prosecutions.*	Non-compliance	The IM is aware of a prosecution involving an environmental incident regarding the May 2011 hydrocarbon spill at the Mine site

MMP Commitment Number	MMP Section reference	Commitment	IM Compliance rating	IM Comment
36	3.3.2	*20% reduction in environmental incidents Category 2 over 2010 performance.*	Compliance	No Cat. 2 incidents reported in the 2011 Operational period, compared with 4 in 2010.
43	4.2.3	*The site wide risk register is reviewed on an annual basis and conducted in line with GEN-SD-PRO-6040-0020 Risk register development and review procedure.*	Compliance	MRM's updated Risk Register is provided as an Appendix to the 2011/2012 MMP
49	4.2.4	*Any environmental incidents that do occur are reported in Site Safe and actions are assigned to staff with appropriate time frames in which to complete.*	Compliance	Incident reports provided by MRM include corrective actions assigned to staff with associated due dates where applicable.
51	4.2.8	*Major environmental risks that are covered in the Emergency Response Plan include:* *Flooding of the open pit;* *Hazardous substance spills;* *Cyclones; and* *Fire*	Compliance	These risks are covered in the Site Emergency Response Plan 2011-2012.
52	4.2.9	*The monitoring conducted at MRM is specified primarily in the WMP and the MMP. An Environmental Monitoring Manual has also been developed which includes the following information:* • *Types of monitoring conducted;* • *Frequency of monitoring;* • *Monitoring locations;* • *Analysis conducted on samples;* • *Laboratories where samples are sent;* • *Dispatch procedures;* • *Invoicing procedures;* • *Data management;* • *Record keeping requirements; and* • *Safety issues associated with monitoring activities.*	Partial Compliance	Environmental Monitoring Manual dated November 2011 has been reviewed by the IM. The listed information is included in the plan, however, monitoring locations do not match those outlined in the 2011/2011 MMP.
54	4.2.9.1.2	*Additional dust monitoring sites will be implemented during early 2011 based on Independent Monitor comments.*	Compliance	Dust gauges were implemented in 2011 at Bing Bong Port, and
55	4.2.9.1.4	*Depositional dusts sampled undergo laboratory analysis on a monthly basis .Parameters analysed are:* *Total Insoluble Matter (TIM); and* *Total Pb, Zn.*	Compliance	Dust monitoring results reviewed by the IM.
57	4.2.9.1.5	*At the time of writing this report further works had commenced to encapsulate the remainder of Cell1 (39%). This work will continue until the 2010 wet season.*	Compliance	Observed by the IM during the 2011 site inspection

MMP Commitment Number	MMP Section reference	Commitment	IM Compliance rating	IM Comment
58	4.2.9.2.2	*Soil samples are collected from locations adjacent to the dust samples sites.*	Compliance	Soil and dust sampling and analysis reviewed by the IM
59	4.2.9.2.2	*Additional soil monitoring sites will be implemented in line with the additional dust monitoring sites.*	Compliance	Soil sampling and analysis reviewed by the IM
60	4.2.9.2.3	*Samples are collected on an annual basis, immediately prior to the wet season (usually October).*	Compliance	Soil sampling and analysis reviewed by the IM
61	4.2.9.2.4	*Parameters analysed are:* *Particle size distribution;* *Paste Ph, EC;* *Major cations: Ca, Mg, Na, K ; and* *Metals: As, Cd, Cu ,Fe, Pb and Zn (2mm fraction)*	Compliance	IM Has reviewed soil monitoring data within the 2011/2012 MMP.
62	4.2.9.3	*Structural surveillance of the TSF and associated infrastructure is conducted regularly, in accordance with site procedure MET-GEN-GDL-2800-0001.*	Compliance	TSF Operating Guidelines, July 2011 TSF Infrastructure inspection reports reviewed.
63	4.2.9.3.1	*Tailings are analysed on a monthly basis for their oxidation characteristics. These analyses include ANC (Acid Neutralising Capacity), NAPP (Net Acid Producing Potential), MPA (Maximum Potential Acidity) and NAG (Net Acid Generation).*	Compliance	2011/2012 MMP
64	4.2.9.4	*McArthur River is rehabilitating the constructed Barney Creek and the McArthur river channels.*	Compliance	The IM has observed rehabilitation efforts over the past 5 years. However, downstream sections of both diversions still require revegetation.
65	4.2.9.5	*MRM is committed to conducting a riparian bird monitoring program to assess the impacts of the McArthur River diversion on riparian fauna and to measure the rehabilitation success of the Barney Creek and McArthur River re-channeling works.*	Compliance	Riparian Bird Monitoring reports reviewed by the IM
66	4.2.9.6	*A condition of the Commonwealth Government approval for the expansion of the McArthur River Mine is to monitor and conduct surveys of listed migratory waders and other birds in the Port McArthur area.*	Compliance	IM has reviewed Migratory Bird Monitoring reports May 2011, and March 2011.
67	4.2.9.7	*Routine adult mosquito monitoring commenced at McArthur River Mine in September 2009, with trapping using six traps. Two of these traps were situated at Bing Bong with the remainder situated around the mine.*	Compliance	Mosquito Monitoring Report 2010/2011 (dated July 2011) reviewed by IM.
69	4.2.9.8	*Ecological Management Services Pty Ltd was commissioned by MRM in early 2010 to conduct an assessment of wallabies in the vicinity of the Bing Bong Loading facility as community concerns had been raised through the Independent Monitor.*	Compliance	Report: 'Bing Bong Macropod Assessment May 2010', was reviewed by the IM as part of the previous Audit conducted in 2011.

MMP Commitment Number	MMP Section reference	Commitment	IM Compliance rating	IM Comment
73	4.2.9.10	*Some of this waste material has been tracked.*	Compliance	This commitment refers to the measurement of waste, which has been
74	4.2.9.10.2	*All contaminated waste is disposed of within a designated area of the Tailings Storage Facility (TSF).*	Compliance	Independent Monitor has observed the contaminated waste dump during previous site inspections. This area was flooded during the 2012 site inspection.
75	4.2.9.10.2	*Bing Bong has a contaminated waste collection area at the Bing Bong port facility. Contaminated waste is stored in a bunded collection point and transported to the TSF designated area as required.*	Not Verified	Waste collection area not inspected by IM this audit.
76	4.2.9.10.3	*Putrescible waste is disposed of in a series of trenches located in the south-eastern corner of the Water Management Dam at the TSF. This waste is periodically burnt.*	Compliance	Independent Monitor has observed the contaminated waste dump during site inspections. However, the IM has observed that other wastes that are non-putrescible (such as tins) were also included in this area.
79	4.2.9.11	*MRM has a Weed Management Plan which is implemented with the assistance of the Weeds Branch in Katherine through annual visits by the district Weed Officer.*	Compliance	Weed Management Plan 2011-2012 reviewed by the IM. The district Weed officer visited the mine in October 2011.
80	4.2.9.11.1	*During 2011 control of Parkinsonia will focus on the McArthur River channel as they shoot along with several plants identified on the internal Western Overburden Emplacement Facility behind the warehouse.*	Compliance	Review of Weed Management Plan 2011-2012 and MRM Weed Management 2010-2011 & 2011-2012 document by the IM.
81	4.2.9.11.2	*During 2011 aerial spraying will continue in this area around the station. Opportunistic spraying along the channel using backpacks will also occur if required.*	Compliance	Weed Management plan 2011-2012 was reviewed by the IM. Aerial spraying was conducted on Devils claw infestations adjacent to the Old McArthur River Homestead and grass species at the airport. Backpack spraying along the channels continues to occur.
82	4.2.9.11.3	*During 2011 efforts will again be placed on Barney Creek however additional resources will also be placed on the McArthur River rehabilitated regions.*	Compliance	Weed Management Plan 2011-2012 review by IM. Spraying and hand-pulling of Noogoora Burr conducted.
83	4.2.9.11.5	*Education will continue during inductions at MRM on weed management with interactive identification of several of the known weed species around site.*	Not Verified	Not verified this audit

MMP Commitment Number	MMP Section reference	Commitment	IM Compliance rating	IM Comment
88	6.2	*Over the next operational year the main areas of rehabilitation will include:* • *Progressive earthworks for rehabilitation of the Northern OEF;* • *Stage one of rehabilitation, over the remainder of cell one at the Tailings Storage Facility (TSF);* • *Continued rehabilitation of the McArthur River Channel; and* • *Maintenance rehabilitation on the Barney Creek Channel.*	Compliance	These areas of rehabilitation were inspected by the IM during site inspections in 2011 and 2012. While the OEF is not yet at a stage ready for rehabilitation, the design of the OEF forms part of the preparation for eventual planned rehabilitation.
89	6.4	*To achieve the above objectives for rehabilitation and ultimate closure, MRM has established the following measures:* • *an unplanned and Life of Mine Completion Plan (LOM);* • *rehabilitation requirements, plans and timelines, which are annually reviewed;* • *security and decommissioning life of mine costs which are calculated annually;* • *a rehabilitation accrual, which is annually reviewed; and* • *post-mining land use objectives, which are reviewed annually.*	Compliance	The IM has reviewed the following documents containing closure and rehabilitation information and security calculations: Mine Closure Plan, Phase 3, January 2012 Rechannel Rehabilitation Plan, November 2011 2011/2012 MMP 2010/2011 MMP
90	6.5.1.1	*Species will be planted on the slopes in similar locations to where they occur naturally.*	Compliance	Vegetation observed during IM visit. IM understands difficulty of revegetating lower slopes and has suggested trials which could be conducted.
91	6.5.1.1	*In addition to slope revegetation it is also proposed that, where practical, vegetation be established along a 20 m wide strip above the batter slopes (as the extension of batter slope vegetation).*	Compliance	Revegetation was observed above the batter slopes by the IM during the site visit.
92	6.5.1.2	*In order to facilitate faster growth rates and better survival rates over the dry season MRM are employing the use of a water sled with irrigation sprinklers.*	Compliance	Water sled was observed by the IM during site visits.
93	6.5.1.3	*Regular monitoring and feedback will be important during revegetation.*	Not verifiable	This commitment does not prescribe a specific action to be verified.

MMP Commitment Number	MMP Section reference	Commitment	IM Compliance rating	IM Comment
94	6.5.4	*The OEF will contain potentially acid forming (PAF) material and non acid forming (NAF) material, with the PAF material encapsulated in a dedicated cell in the western area of the OEF.*	Compliance	IM observed areas of PAF dumping at the NOEF to be encapsulated by NAF, consistent with design. However, the IM cannot definitively confirm the correct identification of NAF or PAF material.
96	6.7	*In August 2010 further capping commenced on cell one aiming to complete it before the 2010/2011 wet season.*	Compliance	Observed during IM site inspections in 2011 and 2012.
98	6.8	*During the 2010/2011 wet season efforts will focus on the lower regions of Barney Creek and flatter zones at the top of the batter.*	Compliance	MRM Rehab Jan-June 2011 document reviewed by IM. Observed during IM site inspection in 2012
99	6.8	*Approximately 40,000 tube-stock were planted on top of the batters with species such as Nauclea orientalis and melaleuca's being planted out sporadically throughout the length of the channel at the toe of the batters and in softer areas.*	Compliance	Occurred during 2010. 2010-2011 MMP and MRM Planting register reviewed by the IM.
100	6.8	*During 2011 additional plants will be sourced from both nurseries in town and through the propagation of seedlings on site.*	Compliance	Plant Nursery invoices and MRM propagation register reviewed by IM. Plant nursery visited during 2012 IM site visit.
101	7.2.7	*The geochemical data is logged in the drilling database, enabling NAF and PAF to be modelled in the geological block model. Further confirmation of this modelling is done using grab samples from the mining areas, which are assayed in the lab before excavation takes place.*	Compliance	NOEF Testing Database excel file provided. NOEF as built Survey by month 2011
102	7.2.7	*Monthly samples are taken in line with procedure MIN-TEC-PRO-1000-0015-EOM NOEF Sampling Procedure, to ensure the correct classification and dumping location of the material.*	Compliance	EOM NOEF Sampling Procedure Reviewed EOM NOEF sampling analysis results provided.
104	7.4.3.4	*The PAF dams consist of two portions, a sediment trap dam first, where any runoff and/or leachate will flow into; and a main dam. Runoff from the OEF spills into the sediment dam first.*	Not verified	Not verified this audit period.
105	7.4.3.4	*The PAF dams are constructed with a compacted clay core, followed by rock armouring to protect them from erosion.*	Not verified	Not verified this audit period.

MMP Commitment Number	MMP Section reference	Commitment	IM Compliance rating	IM Comment
106	7.4.5	*Works planned for the Reporting Period (2011) are:* • *Create a new main ramp onto the NOEF where the powerlines were originally located;* • *Complete the NAF base to W10;* • *PAF cells W4 and W5 will be completed and capped, and W6 and W10 will be in progress;* • *Topsoil will be stripped east to the powerlines and stockpiled;* • *NAF waste will be placed in stages E1, E2 and E3;* • *Clay will be stockpiled in the far northeast corner for later use;* • *Install culverts on the south edge of the NOEF base layer to ensure runoff from the PAF cells can enter the south dams unimpeded;* • *Lysimeters will be installed in the NOEF;* • *Leachate test piles will be established for various PAF and NAF materials to enable larger scale tests of leaching rates and leachate quality;* • *The East Bund OEF for NAF may be commence, pending investigations into workshop locations;* • *NAF rock will be dumped in the north of the pit for a new screening plant site;* • *The surface of the West OEF may be altered to suit construction of infrastructure facilities;* • *The Main Bund will have more NAF material tipped to form the 1:4 external batter and progressively rehabilitated;*	Partial compliance	According to the 2011/2012 MMP, the following items were not undertaken in 2011: • 'Lysimeters will be installed in the NOEF'. This item is planned for 2012; • 'Leachate test piles will be established for various PAF and NAF materials to enable larger scale tests of leaching rates and leachate quality'. Not undertaken as URS disagreed with the IM that this item was necessary. • 'The Main Bund will have more NAF material tipped to form the 1:4 external batter and progressively rehabilitated'. This was not undertaken as water inflow investigations were being firstly undertaken.
		• *Investigations into clay resources on site will be conducted to quantify suitable clay resources for LOM capping requirements. Most of the alluvials mined in stages G and F (around the old river bed) have been too*		

MMP Commitment Number	MMP Section reference	Commitment	IM Compliance rating	IM Comment
107	7.8.1	*Work will continue on constructing the 1:4 sloped outer NAF shell in the eastern and southern areas.*	Compliance	Observed during the IM May 2012 inspection.
115	7.11.8.2	*Tailings will be placed using a spigotted discharge system around the cell perimeter, which will minimise the risk of seepage from the TSF.*	Compliance	IM observed tailings deposited to form beaches around the perimeter of Cell 2.
116	7.11.8.2	*The tailings will be deposited sub-aerially in thin layers to maximise the density of the tailings beach against the embankment, providing a low permeability beach of tailings between the decant water pond and the perimeter embankment.*	Non-compliance	The IM observed the tailings being deposited 'aqueously' in Cell 2 in both 2010 and 2011.
118	7.11.8.3.3	*The design is in progress now for upstream lifts to commence on Cell 2 in 2011.*	Compliance	As per conversations with Metallurgy Manager during 2012 site inspection.
119	7.11.8.3.3	*Operations will continue with the strategies developed this year to further reduce the water inventory in cell 2. Additional mechanical evaporation will be employed once favourable weather conditions return.*	Compliance	Evaporative fans were utilised at Cell 2 over the Operational Period. This is also documented in the 2011/2012 WMP, correspondence to the DME dated 12 November 2010.
123	7.12	*Concentrate is transported from the mine site to Bing Bong by road-trains with covered, side-tipping trailers.*	Compliance	This has been observed by the Independent Monitor during inspections.
124	7.14	*The cargo hold of the Aburri is washed down at the completion of unloading operations. The gutters along each side of the Aburri allows for the decks to be hosed off, with the water collected in a sump near the stern ramp. Water used during the wash-down process is collected on-board and pumped to the Site Run-off Pond.*	Not verified	While this commitment could not be verified by the IM as this was not observed during the site inspections.
126	7.15.1	*Ground work such as additional ripping within the older areas and ground preparation for trials in a section of pond (A) are to be undertaken late in 2010.*	Not verified	Not verified this audit period.
127	7.15.1	*Additional works on the dredge spoil in preparation for the 2010/2011 wet season has already commenced with perimeter walls being strengthened and spillways between ponds removed to ensure a free flow of water ensuring no overtopping occurs.*	Compliance	Observed during 2012 IM Inspection

MMP Commitment Number	MMP Section reference	Commitment	IM Compliance rating	IM Comment
129	7.16	*As covered in section 3.8 of the WMP an additional pond for emergency uses has been constructed at Bing Bong recently. This pond will allow additional evaporation throughout the dry season in future years but also provide a safety net in periods of high rainfall.*	Compliance	Observed during 2012 site inspection
132	8.1.1	*A preliminary Mine Closure Plan has been developed for the McArthur River Mine Site which will be reviewed every 5 years and thus will be completed again in 2013.*	Compliance	Mine Closure Plan, dated January 2012 reviewed.
135	8.3.1	*Over the next reportable period (2011) the following area will be rehabilitated:* • *McArthur River Channel with the use of direct seed and tube stock; and* • *Additional planting along Barney Creek on flatter and downstream regions;* • *Further section of the Mine levee wall.*	Compliance	MRM Rehab Jan-June 2011 document, MMP 2010-2011, MMP 2011-2012, MRM planting register and Trial Irrigation for grasses document reviewed by IM.

APPENDIX D LIST OF DOCMENTS PROVIDED BY MCARTHUR RIVER MINING

TABLE 23 LIST OF DOCUMENTS PROVIDED BY MRM FOR THE 2011 OPERATIONAL PERIOD AUDIT

Monitoring Area	Requested information	Documents Provided by MRM
Surface water and artificial water monitoring documents.	All surface water and artificial monitoring and investigation data, reports (incl. QA/QC), and interpretation, for all monitoring sites.	Surface Water Data - Quarterly as provided to DoR
		ASW Lab & Field Data 2011.xlsx
		Surface water field sheets, COC's
		Artificial field sheets, COC's
	Updated OPSIM Modelling reports, and all other water balance data and reports.	OPSIM report Final.pdf
		BBong_Water Balance Results_110903.xls
		Water Balance Results_110903.xls
		GoldSim Model.docx
		Calibration Plots 2010_2011.docx
		110905 Existing MRM Water Circuit.emf
		110905 Existing BB Water Circuit.emf
		Scope and proposal by WRM for 2012-2013 water balance.pdf
	All external consultants' reports or non-routine internal reports relating to surface water and artificial waters conducted over the monitoring period.	Chapter 10 - Water Resources.pdf
		Appendix D3 - Surface Water.pdf (Specifically chapter 8)
	Please provide an update/the results of analysis and/or relevant reports relating to monitoring of 'white material' observed at the Surprise Creek Bridge near the Carpentaria Highway on 1 Dec 2010.	RE Testing of Salts.msg
		11010 MRM Surprise Ck Ecotox_IPE031011.pdf
		ALS Solid formatted.xlsx

Monitoring Area	Requested information	Documents Provided by MRM
		ALS Water formatted.xlsx
	Actions at Bing Bong in order to manage water	**Bing Bong Shed**
		3200C40026 A Concentrate Storage Shed Guttering-GA.pdf
		3200C80007_A Concentrate Shed Storm Water Tank-Detail.pdf
		3200C80008_A Concentrate Shed Storm Water Tank-Plumbing.pdf
		3200C80009_A Concentrate Shed Storm Water Discharge-Layout.pdf
Groundwater monitoring	All groundwater monitoring and investigation data, reports (incl. QA/QC), and interpretation, for all monitoring sites.	**2011 GW Data Provided (as per quarterly data)
		Field sheets, COC etc
	Information and rationale for any additional groundwater monitoring bores installed during the monitoring period, or any bore decommissioning or destruction.	Additional bores proposed around NOEF and Bing Bong for 2012 (refer to Bing Bong Loading Facility Monitoring Plan)
	All external hydrogeological consultants' reports or non-routine internal reports over the monitoring period for Bing Bong and the Mine site.	Reports
		2011 EM survey for the TSF
		Proposed hydrological Input.pdf
		Review of Seepage Mitigation measures.PDF
		13114400 Water Inflow Containment .pdf
		42213980 MRM EM34 Survey 2011 Final .pdf
		Appendix D4 - Groundwater.pdf
		MRM Progress Report soil con systems.pdf
		MRM Proposal REV4 Water Inflow Interdiction Containment Open Pit 02022012.pdf
		MRM Proposal REVISED Water Inflow Interdiction Containment Open Pit 03082011.pdf
		MRM Xstrata Zinc Proposal Inflows Open Cut Pit 30052011.pdf
		Hatch Water Balance Review.PDF
		Review of groundwater inflow into pit.pdf
Dust, soil and sediment monitoring	All dust, soil and fluvial sediment monitoring and investigation data (incl. QA/QC), and interpretation reports - for all monitoring sites at the Mine Site and Bing Bong.	Results
		Dust Data 2011.xlsx

Monitoring Area	Requested information	Documents Provided by MRM
		Fluvial Sediment Data 2011.xlsx
		Soil Data 2011.xlsx
		Field sheets, COC etc
	Please provide information on any operational or infrastructure changes MRM has adopted to address dust migration at the Mine Site and Bing Bong Port over the monitoring period.	A High Flow Water dispensing tank has been constructed in mining to allow water carts to fill up more efficiently. More sprinklers have been placed around site in order mitigate dust along with evaporating water. Pacrim crushing facilities have made improvements and work has commenced on the dust extraction set up at Bing Bong
		Bing Bong
		emails about dust extraction set up at Bing Bong.pdf
		Dust control scope for Bing Bong .pdf
		extraction schematic.PDF
		extraction schematic.2.pdf
		Signed Tender Schedule.pdf
		Site and Pacrim
		Schematic of PACRIM dust supression.pdf
		Site Layout of dust suppression at Pacrim.pdf
		Email on dust suppression works at Pacrim Works.pdf
		Schedule of works for Pacrim .pdf
		Items required for dust suppression at Pacrim.pdf
		Part list for Pacrim upgrade.xls
	Please provide information and rationale for any changes to monitoring procedures, reporting procedures, or changes/additions to the dust soil or sediment monitoring programs.	Additional sites were added to the program in 2011as per IM recommendations. E.g. Bing Bong swing basin south side of the River
		What MRM now have on site to be implemented this year
		Proposal that was accepted for site on monitoring.pdf
		MiniVol_Flyer.pdf
		TEOM Specifications.pdf
		New Monitoring system.pdf
		Air resources Manager.pdf
		Monitoring shed.pdf

Monitoring Area	Requested information	Documents Provided by MRM
		monitoring shed 2.pdf
	Any external consultants' reports produced over the monitoring period relating to dust, soil and sediment.	Appendix D5 - Air Quality & Greenhouse Gas.pdf
		Evaporative Fan Modelling
		August 2011 Report V1 0.pdf
		October 2011 Report.pdf
Marine Monitoring	All marine monitoring and investigation data, reports (incl. QA/QC), and interpretation, for all monitoring sites including (but not limited to): - lead isotope and metal concentrations in suspended and beach sediments; - Metal concentrations in seawater, sediments and biota; and - water parameters collected during sampling, incl. Turbidity, pH, etc...	2011 Marine Water Data in File
		2011 Marine Sediment Data in file
		Field sheets, COC etc
		MRM/AIMS monitoring data associated with the Annual Survey x2 spreadsheets
		DGT Data for AIMS spreadsheet x 1
	Please provide information and rationale for any changes to monitoring procedures or additions to marine monitoring.	Proposal from Indo pacific which has been accepted for the 2012 Annual Marine program, highlighting changes such as sampling at the mouth of the McArthur River, additional samples and additional time within the sample areas (IPE MRM Monitoring 130212)
		Additional Monitoring has also been proposed within the Bing Bong Environmental Monitoring Plan prepared for NRETAS
	Any related external consultants reports produced over the monitoring period, including those conducted by academic institutions (i.e. Charles Darwin University).	Reports
		2011 Annual Seagrass report
		2011 Vibrio report
		Still awaiting Annual Marine Monitoring report undertaken in 2011
		Still awaiting Annual Marine Transhipment Area report undertaken in 2011
		Still awaiting DGT Report for 2011
		DGT Report for 2010 (dated March 2011)
Flora monitoring	All flora monitoring and investigation data, reports (incl. QA/QC), and interpretation, for all monitoring sites, including (but not limited to):	Reports

Monitoring Area	Requested information	Documents Provided by MRM
	- riparian vegetation monitoring; - weed management; - revegetation along the McArthur River and Barney Creek diversions	
		CDU 2011 Vegetation Report
		Associate Appendices (1-4)
	Any external consultants' reports produced over the monitoring period.	Reports
		Appendix D7 from 2012 EIS Terrestrial Flora
	Please provide information and rationale for any changes or additions to any flora monitoring programs.	As per reports more info on analogue sites
	Please provide an update and rationale regarding any changes to the river diversion revegetation and weed management approaches undertaken during the 2011 Operational Period.	Weed documentation
		MRM_DigitalFieldSheet_Q1_2011.xls
		MRM_DigitalFieldSheet_Q4_2011.xls
		Weed control record sheets 2011 (1).pdf
		Weed control record sheets 2011 (2).pdf
		Weed control record sheets 2012 (1).pdf
		MRM_Chemical storage register_2012(CC).xls
		DigitalFieldSheet.xls Q1 2012.xls
		MRM Weed Management 2010-2011 & 2011-2012.doc
		Fencing and Cattle
		Invoice 1 for fencing.doc
		Invoice 2 for fencing.doc
		Invoice 3 for fencing.doc
		Invoice for muster 1.pdf
	Rehabilitation	Rehabilitation documentation for all of site and Bing Bong
		Scope of works for channel rehabilitation conducted in 2011
		Rehab Maps for 2011
		110323 Plant densities and planting rates.xlsx
		110420 Darwin Plant Wholesalers invoice #39758-39759.pdf
		Barringtonia acutangula seed

Monitoring Area	Requested information	Documents Provided by MRM
		propagation.doc
		GA successful quote.doc
		IL successful quote.doc
		Ironstone Lagoon_April_2011_mcarthur river.pdf
		McArthur Diversion Planting Register 2011 April - Dec 2011.xls
		McArthur Diversion Planting Register 2012.xls
		MRM trees.pdf
		MRM_Rehab_Jan-Jun2011.doc
		MRM_Seed propagation register_18Nov10(JD).xls
		MRM_Seed storage register_ 12Feb2012.xls
		MRM_tubestock storage register.xlsm
		Scope of Works for channel rehabilitation.docx
		Scope of works for irrigation trial.docx
		Tree planting trial.pdf
		Trial irrigation for grasses.doc
	Any available aerial photographs of the river diversion area from the 2011 operation period and previous periods to monitor any erosion.	Refer to latest SDMMP Appendices
	Any updated reports or data on the CDU assessment of vegetation in the Bing Bong rehab area.	None undertaken
Fauna monitoring	All fauna monitoring and investigation data, reports (incl. QA/QC), and interpretation, for all monitoring sites, including (but not limited to): - endangered species monitoring; - migratory bird monitoring; - riparian bird monitoring along the McArthur River and Barney Creek channels;	Reports
		Birds
		Migratory Birds March report 2011
		Migratory Birds final April report and Appendix 2011
		Migratory birds February study 2012
		Riparian bird survey May 2011
		Riparian Bird Survey September 2011
		Mosquito's
		Final Mosquito Monitoring Report 2010/11

Monitoring Area	Requested information	Documents Provided by MRM
		Aquatic Macroinvertebrates
		Aquatic Macroinvertebrate 2011 report
		Fish Etc
		Fish Survey 2011 October Final report
		Fish Survey 2011 May Final report
		MRM fish tagging register
		ADM-ENV-REG-6040-002 Fauna Register I001 Rev 0.xls
		MRM Feral Animal Register.xls
	Any external consultant's reports produced over the monitoring period.	Reports (In fish folder)
		Terrestrial and Aquatic Fauna report for EIS, Terrestrial Flora Report for EIS
		Ecological Assessment of trigger level proposal
		Survey of fish of Surprise and Little Barney Creeks September 2011
		King Ash Bay fishing club/Info fish Tagging Program
		Ecotoxicology Report of sulphate on aquatic biota in surprise Creek at MRM October 2011
		Plan for establishing trigger values for McArthur River discharge Waters 2012
		Ecotoxicity Evaluation of McArthur River Mine Levee Water 2011
	Please advise if the Dingo and Wallaby count survey went ahead last year (2011), and provide any data/reports. The Independent Monitor is unclear whether it was going to happen.	MRM closed the issue on the first survey and thus hasn't been continued
Tailings Storage Facility (TSF)	All geotechnical, hydrogeological, and geochemical monitoring data, inspection reports and updated procedures.	Artificial water testing results for WMD and cell 2 under ASW Lab & Field Data 2011.xlsx
		28PI03 Thickness Test.xlsx
		Product Assay Data 2011.xlsx
		Monthly Reports
		2011 02 28 TSF Infrastructure Inspection.docx
		2011 03 14 TSF Infrastructure Inspection.docx

Monitoring Area	Requested information	Documents Provided by MRM
		2011 04 27 TSF Infrastructure Inspection.docx
		2011 05 31 TSF Infrastructure Inspection.docx
		2011 05 May TSF Monthly Report.docx
		2011 07 20 TSF Infrastructure Inspection.docx
		2011 08 29 TSF Infrastructure Inspection.docx
		2011 08 June July August TSF Monthly Report.docx
		2011 09 September TSF Monthly Report.docx
		2011 10 06 TSF Infrastructure Inspection.docx
		2011 10 06 TSF Infrastructure Inspection.pdf
		2011 10 October TSF Monthly Report.docx
		2011 11 November TSF Monthly Report.docx
		2011 12 December TSF Monthly Report.docx
		MET-PROD-FILEN-111013-TSF Survey Monument Update.docx
		tailings wall monitor.xls
		Risk Verification Sign Offs
		Cat Hazards - HHA's Management Plans.pdf
		CHMP 2H 2010 Uncontrolled Release of Tailings.pdf
		CV 1H 2011 Breach of return (old tailings) line.pdf
		CV 1H 2011 Failure of TSF Rehabilitation for Closure.pdf
		CV 1H 2011 Fence around TSF damaged by flooding.pdf
		CV 1H 2011 Uncontrolled release of tailings CATASTROPHIC HAZARD.pdf
		CV 2H 2010 Uncontrolled release of tailings_CATASTROPHIC HAZARD.pdf
		CV 2H 2011 Breach of return line (old tailings pipeline).pdf
		CV 2H 2011 Fence around TSF damaged by flooding.pdf
		CV 2H 2011 Instability of materials on tailings dam.pdf

Monitoring Area	Requested information	Documents Provided by MRM
		CV 2H 2011 Uncontrolled release of tailings_CATASTROPHIC HAZARD.pdf
		CV 2H 2011 Water containing salt and metals seeping through floor of Cell 1.pdf
		CV 2H 2011 WMD Spillway Overtopping.pdf
	Any evidence of further hydrogeological investigations of mitigation measures at TSF Cell 1. Such as: - further drilling along the main salt breakthrough pathway to determine the degree of fracturing in the underlying rock (dolomite/shale); - understanding of the weathering behaviour of the tailings; - installation of a leachate collection trench/cut-off wall; and - infilling of the geopolymer barrier.	Seepage modelling scope.pdf
	All external consultants reports relating to the TSF, including: - Hydrogeological and water balance ("OPSIM") reports; - Tailings geochemistry reports - for all cells; - Geotechnical and closure/rehabilitation reports (internal and externally prepared).	Consultant Reports
		Cell 2 development Upgrade.pdf
		e002-a_MRM Emergency Action_.pdf
		Stage 2 Development Options Assessment (l001-a).pdf
		water-tailings management.pdf
		Water Management
		1155-01 Tailings Dam Cell 2.pdf
		1155-02 Water Management Dam.pdf
		2011 01 27 Catchment Capacity Update.docx
		2011 03 01 TSF Catchment Capacity Update.docx
		2011 03 15 TSF Catchment Capacity Update.docx
		2011 04 11 Tailings Deposition Strategy for April.docx
		MET-PROD-RPT-091124-TSF Dam Levels and Rainfall Reporting Spreadsheet.xlsx
		Tailings Dam Ponds Assessment Rev2.pdf
	Evidence of actions undertaken to reduce the amount of water stored in Cell 2 since May 2011 (the Independent Monitor's last site inspection).	Investment Proposals
		2011 02 06 TSF Cell 2 South Wall

Monitoring Area	Requested information	Documents Provided by MRM
		Tails Line Ext Invest Prop form.doc
		2011 06 23 WMD piping infrastructure Investment Proposal.docx
		14117300 - WATER MGMT PIPING WMD.pdf
		14118300 - TSF Cell 1 Water Shedding.pdf
		Budget Capex 2012.xlsx
		TSF Construction BOQ rh09022012.xlsx
	Details or documents relating to any further works on the surface capping of TSF 1 - such as shaping of the cap. This was a commitment that was not met last audit.	Rehabilitation
		110211 Tailings dam Cell 1 direct seeding - JD - File Note.doc
		seeding 1.JPG
		seeding 2.JPG
		Scope of works for tailings dam.docx
		Invoices for rehab earthworks.pdf
		2quarter rehabilitation area maps.pdf
		MRM_DirectSeeding_Jan-Jun2011.JPG
		1211 4800 TSF Clay Capping approved.pdf
	Any incident reports relating to the TSF for the monitoring period.	N/A
Overburden Emplacement Facility (OEF)	All updated procedures, monitoring data, reports (incl. QA/QC), and interpretation relating to: - waste rock handling; - geotechnical monitoring; - testing of the clay liner.	MIN-TEC-PRO-1000-0015 EOM NOEF Sampling Procedure MIN-TEC-PRO-1000-0025 NOEF As built Review and Sign Off Procedure MIN-TEC-PRO-1000-0025 Clay Liner Quality Control and Construction at the NOEF
		EOM_NOEF NAF Sampling.xlsx
		NOEF TestingDatabase.rev01.xls
	Monthly Reports	January - December 2011 MRM Geotechnical Monthly reports
		2011 MRM Weekly OEF reports
		2011 HSEC monthly Inspections of mining area including OEF
	All external consultants reports prepared over the monitoring period, including Life of Mine closure plans (relevant to the entire operation), rehabilitation studies, etc.	Reports
		Resource Model Update Report_final.pdf

Monitoring Area	Requested information	Documents Provided by MRM
		Proposal on hanging wall model.pdf
		NOEF Review Scope_WRM.pdf
		Stage 7 KLC 110510 Stage 7 KLC Program Update - April 2011_M003_R001.pdf
		111129 URS kinetic leach Stage 7 Draft report .pdf
	Design reports and as-built reports relating to the OEF. We understand that Construction Reports are available in 'Vulcan' Software. Please provide an export of the report to the Independent Monitor in a format that is readable without Vulcan.	NOEF as built Survey by month 2011.docx
		NOEF 6 month composites.zip
		NOEF Topsoil Strip.docx
		topsoil_post_strip.dxf
		Lysimiters
		Proposal for Design of Lysimeters.pdf
		Draft Lysimeter Design Report.pdf
		Lysimeter Construction Estimate for Mining.xlsx
		Draft Design BOQ.xlsx
		111115 file note.docx
		111110 File Note.docx
Bing Bong dredge spoil	All monitoring data, reports (incl. QA/QC), and interpretation relating to: - vegetation monitoring/surveys; - Accelerated salt leaching; - soil monitoring; - water monitoring; and - Geotechnical monitoring. At or surrounding the Bing Bong Dredge spoil.	Field sheets, COCs, etc…
		Bing Bong Dredge Spoil Drain Data 2011.xlsx
		Dredge Spoil Drain Sediment Data 2011.xlsx
		Soil around Spoil pond
		Soil within ponds
	All available design reports, as-constructed reports, surveyed plans and photographs relating to the design and functioning of the Bing Bong dredge spoil pile walls and drain.	Info on Bing Bong Dams.pdf
	Examples of periodic dredge spoil site inspection reports and procedures.	Monthly HSEC Inspections
		Bing Bong spoil Inspection January.pdf

Monitoring Area	Requested information	Documents Provided by MRM
		Bing Bong spoil Inspection February 1.pdf
		Bing Bong spoil Inspection February 2.pdf
		Bing Bong spoil Inspection March.pdf
		Bing Bong spoil Inspection April.pdf
		Bing Bong spoil Inspection May.pdf
		Bing Bong spoil Inspection June.pdf
		Bing Bong spoil Inspection July.pdf
		Bing Bong spoil Inspection August.pdf
		Bing Bong spoil Inspection October.pdf
		Bing Bong spoil Inspection November.pdf
		Bing Bong spoil Inspection December.pdf
	Details of any additional dredging, or civil works undertaken at the dredge spoil during the 2010 Operational Period.	Daily Costs Bing Bong for erosion works and dam completion.xlsx
	All external consultants' reports prepared over the monitoring period.	Photos of maintenance work conducted in 2011
		Investment Proposal Rehab Activities at Bing Bong.pdf
		First report on dams AWA
		FW CPT Testing in NT.msg (email on testing)
		RE CPT Testing in NT.msg (email on testing)
River diversion monitoring	All updated procedures, monitoring data, reports, and interpretation relating to: - erosion monitoring; - inspections; - river gauging and flood event monitoring; - placement of large woody debris, and bank armouring; - overall diversion performance.	All gauging station Info
		BCGS
		DSGS
		SCGS
		USGS
		111007 ALS Quote no.10144.pdf
		BCGS 2011 WMP.xlsx
		DSGS 2010-2011.xlsx
		Formatted Barney Creek Gauging Station.xlsx

Monitoring Area	Requested information	Documents Provided by MRM
		Formatted Downstream Gauging Station.xlsx
		Formatted Early warning flood_LevelData.xlsx
		Formatted Surprise Creek Gauging Station.xlsx
		Formatted Upstream Gauging Station.xlsx
		Report for Theoretical Ratings May-2011.pdf
		USGS 2010-2011.xlsx
		Large Woody Debris Report 2011.doc
		Erosion Monitoring (Folder) Photos from start to finish (Note taken both sides now)
	As built drawings of the river diversions (if updated)	None updated however ALS data was collected in 2011
	Please provide information and rationale for any changes or additions to any diversion monitoring programs.	Photos taken on both sides now as per IM recommendations (Refer to folder for all photos)
	Any external consultants' reports prepared over the monitoring period.	Appendix D3 Surface Water section from the 2012 EIS study
		Early Warning Flood system
		1.5m Alarm EarlyWarningFloodSystem.msg
		2m Alarm EarlyWarningFloodSystem.msg
		3m Alarm EarlyWarningFloodSystem.msg
		4m Alarm EarlyWarningFloodSystem.msg
		5m AlarmEarlyWarningFloodSystem.msg
		6m AlarmEarlyWarningFloodSystem.msg
		level notification settings.docx
Diesel Spill, 2011	Please provide incident report, results of analysis and remediation documentation relating to an oil spill reported at the mine site in May 2011.	May 2011 Diesel Spill
		Weekly Updates
		Memo Updates 1-42
		MRM March 2012 Report
		URS August 2011 Report
		URS October 2011 Report
		LETT Signed 28032012 evidence of expenditure.pdf
Hydrocarbon	Hydrocarbon management procedures manual	Procedures

Monitoring Area	Requested information	Documents Provided by MRM
Management		
		ADM-SPL-PRO-6070-0006 To Order ULP I001 Rev 0.doc
		ADM-SPL-PRO-6070-0007 Weekly MRM Fuel Usage Report I001 Rev 0.doc
		ADM-SPL-PRO-6070-0008 To Order Diesel I001 Rev 0.doc
		ADM-SPL-PRO-6070-0009 To Add A Key Onto Transhost I001 Rev 0.doc
		ADM-SPL-PRO-6070-0010 Receipting in ULP I001 Rev 0.doc
		ADM-SPL-PRO-6070-0011 Receipting in Diesel I001 Rev 0.doc
		ADM-SPL-PRO-6070-0012 Processing Shell Invoices I001 Rev 0.doc
		ADM-SPL-PRO-6070-0013 Bing Bong Fuel Records I001 Rev 0.doc
		GEN-OHS-PRO-6040-0026 Decommissioning of Plant and Equipment I001 Rev0.doc
		GEN-SD-PRO-6040-0026 Hydrocarbon Management Procedure I001 Rev 0.doc
	Hydrocarbon spillage clean up manual	As per above procedure
	Hydrocarbon monitoring program(manual)	Refer to Environmental monitoring tech manual for TPH monitoring of water sources
		FW FUEL FARM INFO.msg
		FUEL FARM JOBS.xlsx
		FUEL FARM PRESENT WORK ORDERS.xlsx
		FUEL FARM STANDARD JOBS TANK 1.xlsx
		FUEL FARM STANDARD JOBS TANK 2.xlsx
	Results of internal hydrocarbon audits	Monthly Inspections
		Mcarthur River Warehouse and Storage Areas JP.xls
		Mcarthur River Warehouse and Storage Areas.pdf
		Mcarthur River Warehouse and Storage Areas.xls
		Mcarthur River Warehouse and Storage Areas_AK.xlsx
		Warehouse inspection 11012012 JP.pdf
		warehouse inspection 29092011.pdf

Monitoring Area	Requested information	Documents Provided by MRM
	Results of external hydrocarbon audits	Final Hydrocarbon Audit Report.pdf
		McArthur River Chemical Audit Report 2011.pdf
	Inspections and follow up work	3200C60034 A Diesel Day Tank-GA.pdf
		ABU012 Bunkering.pdf
		ABUFM06 ShipshoreSafetyCheck.pdf
		Bing Bong main Tank.pdf
		Certification of diesel tank.pdf
		Report MRM-1118-01 Plant Fuel Tanks.pdf
		Report MRM-1118-02 Plant Fuel Tank 1.pdf
		Report MRM-1202-01 Bing Bong Fuel Management.pdf
		Vertical Diesel Tank No 1.pdf
General reports	2011/2012 Mining Management Plan	Included in the Plan folder along with Appendices
	2010-2011 SD Mining Management Plan (If updated since 2011)	Included in the Plan folder along with Appendices
	2011 Water Management Plan	Included in the Plan folder along with Appendices
	Life of mine closure plan (if updated)	Included under the Plan folder MRM Closure Plan (January 2012)
	Waste management plan (if updated)	Included under the Plan folder (March 2011)
	All environmental incident reports in the 2011 Operational Period	Matt
		ICAMS
		Diesel Spill Bing Bong Port Facility Report.pdf
		DOR Notification Diesel Spill Bing Bong A.pdf
		DOR Notification Diesel Spill Bing Bong B.pdf
		Diesel Spill Site May 2011 Report.pdf
		DOR Notification Diesel Spill May 2011.pdf
		North OEF December 2011 Report.docm
		DOR Notification North OEF December 2011.pdf
		DOR Notification OEF May 2011.pdf
		North OEF May 2011 Report.pdf
		DOR Notification water overflow.pdf

Monitoring Area	Requested information	Documents Provided by MRM
		Water Overflow investigation report.doc
	All community complaints over the 2011 Operational Period	No formal environmental community complaints were made. A database called consultation is utilised to record all community complaints
	All updated management plans and procedures related to environmental monitoring and performance.	Plans, Standards and Policies
		MRM Mine Closure Plan
		Energy Efficiency and GHG Plan 2011
		Technical Environmental Monitoring Manual December 2011 (GEN-ENV-PLN-6040-0001)
		Rechannel Rehabilitation Plan (GEN-ENV-PLN-6040-0005)
		Weed Management Plan 2011-2012 (GEN-HSE-PLN-6040-0006)
		Site Emergency Response Plan (GEN-GEN-PLN-6040-0001)
		SD Water Management Plan (GEN-HSE-PLN-6040-0004)
		SD Mining Management Plan (GEN-HSE-PLN-6040-0003)
		MRM SD Management System Guideline (GEN-SD-GDL-6040-0002)
		MRM SD Annual Plan 2012 (GEN-SD-PLN-6040-0001)
		MRM SD Strategy (GEN-SD-PLN-6040-000)
		MRM Policy (GEN-SD-POL-6040-0002)
		Waste Management Plan (GEN-SD-PLN-6040-0003)
		Leadership, strategy and Accountability Standard (GEN-SD-STD-6040-0001)
		Planning and Resources Standard (GEN-SD-STD-6040-0002)
		Communication and Engagement Standard (GEN-SD-STD-6040-0004)
		Risk and Change Management Standard (GEN-SD-STD-6040-0005)
		Catastrophic Hazards Standard (GEN-SD-STD-6040-0006)
		Environment, Biodiversity and Landscape Functions Standard (GEN-SD-STD-6040-0010)
		Social and Community Engagement Standard (GEN-SD-STD-6040-0012)
		Product Stewardship Standard (GEN-

Monitoring Area	Requested information	Documents Provided by MRM
		SD-STD-6040-0014)
		Monitoring and Review Standard (GEN-SD-STD-6040-0016)
	Please provide an updated list of all existing management plans and procedures currently in use at MRM (whether updated during the monitoring period or not).	Documents/ Procedures
		Fauna Management procedure (ADM-ENV-PRO-6040-0017)
		General spill response procedure (GEN-ENV-PRO-6040-0004)
		Management and disposal of waste oils procedure (GEN-ENV-PRO-6040-0008)
		Management and disposal of waste cooking oil procedure (GEN-ENV-PRO-6040-0009)
		Management and disposal of Aluminium cans (GEN-ENV-PRO-6040-0010)
		Disposal of scrap steel procedure (GEN-ENV-PRO-6040-0011)
		Management of the contaminated waste disposal facility procedure (GEN-ENV-PRO-6040-0012)
		Waste refuse faculty Management procedure (GEN-ENV-PRO-6040-0013)
		Waste tyre and conveyor belt management procedure (GEN-ENV-PRO-6040-0015)
		Management and disposal of cardboard and paper Procedure (GEN-ENV-PRO-6040-0022)
		Disposal of lead acid batteries procedure (GEN-ENV-PRO-6040-0023)
		Disposal of printer cartridges procedure (GEN-ENV-PRO-6040-0024)
		Leadership, strategy and accountability procedure (GEN-SD-PRO-6040-0001)
		Planning and Resources procedure (GEN-SD-PRO-6040-0002)
		Communication and Engagement procedure (GEN-SD-PRO-6040-0004)
		Risk and Change Management procedure (GEN-SD-PRO-6040-0005)
		Catastrophic Hazards procedure (GEN-SD-PRO-6040-0006)
		Environment, Biodiversity and Landscape Functions procedure

Monitoring Area	Requested information	Documents Provided by MRM
		(GEN-SD-PRO-6040-0010)
		Social and Community Engagement procedure (GEN-SD-PRO-6040-0012)
		Product Stewardship procedure (GEN-SD-PRO-6040-0014)
		Risk register development and review procedure (GEN-SD-PRO-6040-0020)
		Hydrocarbon Management procedure (GEN-SD-PRO-6040-0026)
		Land clearing and digging permit procedure (GEN-SD-PRO-6040-0027)
		Water Truck procedure (MIN-GEN-PRO-1000-0020)
		Forms
		Marine sediment monitoring competency assessment (ADM-ENV-ASS-6040-0001)
		Natural surface water monitoring competency assessment (ADM-ENV-ASS-6040-0002)
		Product investigation monitoring competency assessment (ADM-ENV-ASS-6040-0004)
		Sea water monitoring competency assessment (ADM-ENV-ASS-6040-0006)
		Artificial water monitoring competency assessment (ADM-ENV-ASS-6040-0007)
		Dust monitoring competency assessment (ADM-ENV-ASS-6040-0008)
		Fluvial sediment monitoring competency assessment (ADM-ENV-ASS-6040-0009)
		Groundwater monitoring assessment competency assessment (ADM-ENV-ASS-6040-0010)
		Soil monitoring competency assessment (ADM-ENV-ASS-6040-0011)
		DGT monitoring competency assessment (ADM-ENV-ASS-6040-0013)
		Rehabilitation sled- abstraction flow meter reading sheet (ADM-ENV-FRM-6040-0012)
		Permit to dig and clear form (GEN-SD-FRM-6040-0001)
Other audits	Please provide the environmental audit report, any feedback, and/or scope from all: - Commonwealth Government Audits; and - Department of Resources audit of MRM	Audits

Monitoring Area	Requested information	Documents Provided by MRM
	Undertaken during the 2011 Monitoring Period.	
		NRETAS Waste Discharge License Audit letter
		DOR MMP Compliance Audit (Draft, final only in hard copy)
		DOR inspection of Bing Bong
		Xstrata SD Systems Audit
		Commonwealth Draft Audit (2010)
		Xstrata Internal risk audit Tailings Facilties Management October 2011
		Xstrata Internal risk audit Tailings Facilties Management water management October 2011

APPENDIX E LIST OF DOCUMENTS PROVIDED BY THE DEPARTMENT OF MINES AND ENERGY

TABLE 24 LIST OF DOCUMENTS PROVIDED BY THE DME FOR THE 2011 OPERATIONAL PERIOD AUDIT

Document Type	DoR Reference	Trim Date	DME Comment
List of documents associated with 2010 Compliance Audit.			
Email	MDOC20103836	28/10/2010	DoR notification to MRM of audit
Letter	MDOC20104160	23/10/2010	DoR letter notification of audit
Letter	MDOC20104296	30/11/2010	DoR letter notification of audit with criteria
Email	MDOC20104306	01/12/2010	DoR email of criteria for audit
Email	MDOC20104319	01/12/2010	Request for DoR to investigate salt deposits
Letter	MDOC20110201	17/01/2011	DoR letter to MRM with advice on salt deposits
Report	N/A	13/12/2010	Field Inspection Report
Letter/Report	MDOC20110676	22/02/2011	Draft Audit Report sent to MRM
Email	MDOC20110922	08/03/2011	MRM comments on draft audit report
Report	MDOC20110973	11/03/2011	Final Audit Report
Letter	MDOC20111738	29/04/2011	MRM response to final audit report
List of documents associated with 2011 Compliance Audit.			
Letter	MDOC20115726	25/11/2011	DoR letter to inform MRM of audit
Email	Email string.pdf	24/11/2011 to 05/03/2012	String of email documents demonstrating the communication and planning involved in the 2011 MMP Audit.
Itinerary	Audit Itinerary.pdf	31/01/2012	Final itinerary for audit visit
Report	MDOC21121028	03/02/2012	DoR inspection report to close out on audit criteria of ship loading procedures and dust control.
Letter	MDOC20121307	13/03/2012	DoR cover letter for final audit report
Report	MDOC20121310	13/03/2012	DoR Final audit report
List of documents associated with 2011 Hydrocarbon Audit.			
Letter	MDOC20112521	28/06/2011	DoR letter requesting MRM undertake an audit of hydrocarbon facilities
Email	MDOC20113949	07/09/2011	DoR reminder that audit report due – Response from MRM
Report	MR20110423	10/10/2011	Hydrocarbon audit report from MRM
Letter	MDOC20115078	21/10/2011	MRM information on actions following hydrocarbon audit
Letter	MDOC20115796	01/12/2011	DoR acceptance letter
List of documents associated with 2010 – 2011 Mining Management Plan.			

Document Type	DoR Reference	Trim Date	DME Comment
Letter	MDOC20104028	11/11/2010	MRM Letter for MMP and application for an authorisation
Form	MDOC20104029	04/11/2010	Application for authorisation
Form	MDOC20104030	25/10/2010	Application for authorisation
Letter	MDOC20104136	22/11/2010	DoR acknowledgement of MMP
Letter	MDOC20110980	11/03/2011	DoR request for additional information
Letter	MDOC20111332	04/04/2011	MRM request additional 21 days to respond
Letter	MDOC20111754	06/05/2011	MRM additional information
Letter	MDOC20112807	14/07/2011	DoR acceptance and request for security
List of documents associated with 2011 – 2012 Mining Management Plan			
Email	MDOC20115136	26/10/2011	MRM request for extension and DoR acceptance of extension
Letter	MDOC20115419	07/11/2011	MRM Letter for MMP submission
Letter	MDOC20115608	17/11/2011	DoR acknowledgement of MMP
Letter	MDOC20121610	23/03/2012	DoR request for additional information
Letter	MDOC20122709	02/05/2012	MRM response with additional information
List of documents associated with amendment to the 2010 – 2011 Mining Management Plan			
Letter	MDOC2011/3841	30/8/2011	MRM letter requesting amendment to the 2010/2011 MMP.
Letter	MDOC20115119	25/10/2011	DoR request for additional information.
Letter	MDOC20115455	09/11/2011	Additional Information from MRM
Letter	MDOC20115725	25/11/2011	DoR approval of amendment.
List of documents associated with amendment to the 2010 – 2011 Mining Management Plan			
Letter	MDOC20114480	16/9/2011	MRM letter requesting amendment to the 2010/2011 MMP.
Letter	MDOC20115120	25/10/2011	DoR approval of amendment.
Letter	MDOC20112974	21/07/2011	MRM submission of amendment to MMP
List of documents associated with Review of the TSF stability following IM comments			
Letter	MDOC20116028	15/12/2011	DoR direction to undertake a review of TSF and WMD stability
Letter	MDOC20120015	04/01/2012	MRM response
Letter	MDOC20120994	21/02/2012	Consultant Report for Stage 1
List of documents associated with 2010 – 2011 Water Management Plan			
Letter	MDOC20102892	30/08/2010	Submission letter WMP
Report	MR20100367	31/08/2010	Water Management Plan

Document Type	DoR Reference	Trim Date	DME Comment
Letter	MDOC20102924	03/09/2010	Acknowledgement Letter for WMP
Letter	MDOC20103318	30/09/2010	Request for Additional Information for WMP
Email	MDOC20104004	11/11/2010	Request for Extension for WMP
Email	MDOC20104092	18/11/2010	Extension for WMP Granted
Letter	MDOC20104295	30/11/2010	Submission Letter updated WMP
Letter	MDOC20104443	10/12/2010	Acknowledgement of updated WMP
Letter	MDOC20110445	02/02/2011	Conditional approval WMP
Letter	MDOC20111129	15/03/2011	MRM response to conditional approval for WMP
Letter	MDOC20111276	31/03/2012	Acknowledgement from DoR of MRM acceptance of conditions
List of documents associated with 2011 – 2012 Water Management Plan			
Letter	MDOC20113663	24/08/2011	MRM request for extension
Letter	MDOC20113672	25/08/2011	DoR granted extension
Email	MDOC20114102	12/09/2011	MRM request for further extension
Letter	MDOC20114124	13/09/2011	DoR granted extension
Report	MR20110419	30/09/2011	2011-2012 WMP
Letter	MDOC20114618	03/10/2011	Submission letter for WMP
Letter	MDOC20115894	12/12/2011	DoR request for additional information
Letter	MDOC20121825	09/01/2012	MRM request for additional time to respond
Letter	MDOC20120126	16/01/2012	DoR grant extension
Letter	MDOC20120333	20/01/2012	MRM additional information
Letter	MDOC20121064	29/02/2012	DoR request for additional information
Report	MR20120020	02/04/2012	2011 – 2012 WMP resubmission
Letter	MDOC20122161	12/03/2012	DoR conditional approval
Letter	MDOC20122317	19/04/2012	MRM response to approval
Letter	MDOC	31/05/2012	MRM additional information
List of documents associated with the amendment to the 2010 – 2011 Water Management Plan – Evaporation Fans at Tailings Storage Facility.			
Letter	MDOC20104066	12/11/2010	Submission Letter updated WMP including additional information
Letter	MDOC20104261	26/11/2010	DoR approval of 12 month trial
List of documents associated with amendment to the 2010 – 2011 Water Management Plan – Request to discharge from the Water Management dam			
Letter	MDOC20110459	02/02/2011	Request to amend WMP to discharge from WMD to Barney Creek

Document Type	DoR Reference	Trim Date	DME Comment
Letter	MDOC20110462	02/02/2011	DoR request for additional information
Letter	MDOC20110510	04/02/2011	Additional Information from MRM
Letter	MDOC20110499	04/02/2011	DoR request for additional information
Letter	MDOC20110641	17/02/2011	Additional Information from MRM
Letter	MDOC20110638	18/02/2011	Approval with conditions
Letter	MDOC20110867	03/03/2011	Additional Information from MRM and acceptance of approval conditions
Letter	MDOC20110965	10/03/2011	DoR acceptance with conditions
List of documents associated with amendment to the 2010 – 2011 Water Management Plan – Request to use evaporation fans at Bing Bong Facility			
Email	MDOC20110832	01/03/2011	Request from MRM to use Evaporation Fan at Bing Bong
Email	MDOC20110875	03/03/2011	Internal Communication of Approval
Letter	MDOC20111277	31/03/2011	Approval from DoR to MRM
List of documents associated with 2010 – 2011 Mining Management Plan - *Request to discharge water from the Water Management Dam to Barney Creek*			
Letter	MDOC20110984	14/03/2011	MRM request to discharge to Barney Creek
Letter	MDOC20111010	15/03/2011	DoR Request for Additional Information
Letter	MDOC20111042	16/03/2011	MRM additional information
Letter	MDOC20111075	18/03/2011	Approval from DoR
Letter	MDOC20111219	24/03/2011	Additional Information from MRM
Letter	MDOC20111309	01/04/2011	Approval of Additional information by DoR
List of documents associated with amendment to the 2010 – 2011 Water Management Plan – Request to increase discharge from Mine Levee Wall			
Letter	MDOC20111218	24/03/2011	Request in increase discharge rate from Mine Levee Wall
Letter	MDOC20111275	31/03/2011	DoR approval
List of documents associated with amendment to the 2010 – 2011 Water Management Plan – Request to increase discharge from Mine Levee Wall			
Letter	MDOC20111565	19/04/2011	MRM submission
Written procedures for undertaking audits and assessments of the environmental performance of the McArthur River Mine.			
Procedure	CP4 001- Audits and Site Inspection Procedure	-	
Procedure	CP4 002 Audit Checklist	-	
Procedure	CP4 – 004 Audit Grading System	-	
Procedures for assessing/accepting Water Management Plans and Mining Management Plans.			

Document Type	DoR Reference	Trim Date	DME Comment
Procedure	AP2- 003 Document Review Procedure	-	
Procedure	CP1 – 001 Existing Authorisation Administrative Procedure	-	
Procedure	CP1 – 002 Existing Authorisation Checklist	-	
Procedures for sampling and analysis used by the department to undertake check monitoring/environmental sampling.			
Manual	Procedures Manual – Environmental Monitoring Unit (EMU)	-	
Manual	AA7-024 Ground water sampling methodology	-	
Manual	AA7 – 025 Surface water sampling methodology	-	
The Department's check-monitoring reports and data-sets pertaining to 2011 Operational Period			
Report	Environmental Monitoring Unit Field visit report - Final.pdf	-	
Monitoring data	EMU MRM SW GW WQ data 2012.xlsx	-	
List of documents for the Independent Monitor associated with May 2011 Diesel Spill			
Email	MDOC20111695	28/04/2011	Email chain of notification and initial responses
Email	MDOC20111784	10/05/2011	Email chain of MRM asking for extension of report, granted by DoR
Report	MDOC20111923	17/05/2011	MRM investigation Report
Letter	MDOC20112979	21/07/2011	MRM cover letter for monitoring report
List of documents for the Independent Monitor associated with the NOEF sump overflow June 2011			
Form	MDOC20111751	04/05/2011	Notification of incident
Report	N/A	07/06/2011	MRM investigation report
List of documents for the Independent Monitor associated with pipe discharge Nov 2011			
Form	MDOC20115377	07/11/2011	Initial notification of incident from MRM
Report	N/A	N/A	MRM investigation report
List of documents for the Independent Monitor associated with May 2011 Diesel Spill			
Email	MDOC20120018	28/12/2011	Email chain of notification of incident from MRM and initial response from DoR
Email	MDOC20120077	04/01/2012	Query and response as to the status of

Document Type	DoR Reference	Trim Date	DME Comment
			the report into the incident
Email	MDOC20120078	05/01/2012	DoR query about delay of report
Email	MDOC20120104a	06/01/2012	Additional Information from MRM
Form	MDOC20120104b	06/01/2012	Form attached to email
Email with attached report	MDOC20121405	24/02/2012	DoR Email with field inspection report attached.
Letter	MDOC20120998	27/02/2012	MRM letter addressing questions raised in field inspection report.
List of documents for the Independent Monitor associated with the NOEF overflow			
Form	MDOC20120223	13/01/2012	Notification of incident
Report	MDOC20120973	21/02/2012	MRM incident report