



REPORT NO.

211011

## INDEPENDENT MONITOR'S AUDIT OF THE MCARTHUR RIVER MINE FOR THE 2010 OPERATIONAL PERIOD

**ENVIRONMENTAL EARTH SCIENCES VIC**  
REPORT TO THE MINISTER FOR PRIMARY INDUSTRY FISHERIES AND  
RESOURCES  
OCTOBER 2011  
VERSION 1





be brought together by an organisation with competent and experienced hydrogeologists and geochemists. Neither the Golder or the URS studies or reports have achieved this.

The IM 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.

### 9.2.6 General groundwater management conclusions and recommendations

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

- quality control and quality assurance has not been presented or discussed. As described in previous Independent Monitor Audit reports, a discussion on the quality, precision, accuracy and reproducibility of results is an essential component of groundwater and water monitoring reporting in general. This includes, but may not be limited to, a discussion on the comparison of field and laboratory measurements—that is pH in the field and laboratory, TDS/EC ratios—relative percentage differences between discrete and intra-laboratory blind duplicate samples, and findings of the laboratory’s quality control reporting and data set evaluations for confirmation of inconsistencies; and
- 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. Separate groundwater contour figures using all available bores should be provided for the TSF, the regional monitoring network and Bing Bong. 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 Update since the previous audit

With regarding to dust surveillance, the Independent Monitor is pleased to see that MRM have acted upon most of the recommendations made in the last audit report. A summary of the issues identified in the last report in relation to dust monitoring are presented in Table 4 along with the resultant outcomes or updates.

**TABLE 4 UPDATE ON IDENTIFIED ISSUES IN RELATION TO DUST MONITORING**

Independent Monitor Audit observation from 2010 inspection	Has the issue been resolved?	Comment
Tailings storage facility needs to be fully capped to prevent fugitive dust generation	Yes	Capping of Cell 1 is complete. The intent of the capping is for dust suppression only, and is expected to result in reduction of contaminated dust – to be reported in the 2011/2011 MMP.



Independent Monitor Audit observation from 2010 inspection	Has the issue been resolved?	Comment
<b>Dust mitigation needs to be increased at PACRIM area</b>	Incomplete.	During inspection in May 2011, dust was observed emanating from the PACRIM crusher. According to MRM staff an additional hood/cover on the crusher has been added recently. No other significant visible improvements were noted since last inspection. Many dust suppression measures still need to be undertaken.
<b>Concentrate bearing dust was observed on banks of Barney Creek diversion rehabilitation area</b>	Incomplete.	Barney Creek was not visibly affected by concentrate during inspection. However, dust was observed to be emanating from PACRIM, which would have the potential to end up in the Barney Creek flood plain/diversion.
<b>Purchase a street sweeper for the Mill, Barney Creek Bridge and PACRIM yard roads to aid dust suppression</b>	Incomplete	Gary Taylor (pers. comm.) advised that a street sweeper had been purchased, but it was not very effective. The Independent Monitor believes that its use in these areas should be continued as concentrate dust was visible on hardstand surrounding the PACRIM crusher. The Independent Monitor is unaware of the frequency at which the sweeper operates.
<b>Place a vegetation barrier between ROM pad and main road</b>	No	MRM have indicated that this will be undertaken, however no date has been given.
<b>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</b>	Incomplete, but plans are being made.	Doors of the shed are still kept open. MRM have advised that capital expenditure on a negative pressure system has been approved, so doors can be kept shut.
<b>Opportunity for improvement of dust fallout monitoring in Bing Bong swing basin</b>	Yes	There is a new dust monitoring location in the swing basin.
<b>No dust monitoring locations in the vicinity of the OEF</b>	Yes	Two new locations near the OEF.
<b>No dust monitoring locations south of the McArthur River channel</b>	Yes	New dust monitoring location south of the McArthur River channel.
<b>Inconsistency in the requested laboratory analyses. These varied between total solids(TS) and total insoluble matter (TIM).</b>	Yes	MRM now consistently requests TIM, lead and zinc analyses.
<b>Sampling gauges need to be left for 30±2 days as per AS/NZS 3580.10.1:2003.</b>	Incomplete	Compliance has increased since last year's audit, however at least one sampling occasion was noted outside the specified timeframe. It is understood that inclement weather/unsafe conditions may sometimes prevent compliance.
<b>No discussion is provided in terms of spatial or temporal trends with regard to Pb, Zn and TIM results.</b>	Yes and no, discussion/charts are only provided for some monitoring locations	Results are not reported in the MMP for PACRIM: D27, D22 and D21 and other locations: D04, D17, D06, D03, D20, D08, D25, D05 If this is because these results are deemed to be low or not of concern, it should be stated.



Independent Monitor Audit observation from 2010 inspection	Has the issue been resolved?	Comment
The location for gauges D1 and D5 is not shown .	Yes	Locations are shown in MMP map.
TIM, lead and zinc levels have increased over time, especially in Bing Bong, TSF and PACRIM areas.	Yes and no	Generally TIM, lead and zinc levels have not increased but rather remained similar. A notable decrease in measured dust and metal levels is required, specially at the PACRIM.
Laboratory QA/QC documentation was only partially provided.	No	No laboratory QA/QC documentation was provided this year.

### 9.3.2 Observations from site inspection

#### *Mine site*

Dust remains as an issue in this audit. At the mine site the main source of contaminated dust is from the operation of the PACRIM crusher plant. During its May 2011 site inspection, the IM observed dust emanating from the PACRIM plant (Plate 10), and noted dust settled on surrounding objects (Plate 7). No significant improvements to dust management from the PACRIM were observed this audit. However, we do note that MRM have advised that limiting dust emissions completely from this plant may not be possible.

However, MRM staff did advise that an additional hood had been placed on the plant to try to limit dust, and that sprays were working throughout the plant to suppress dust. The IM also observed that a spray at the top end of the PACRIM conveyor line is now used constantly rather than intermittently (Plate 8).

Water trucks were observed to be operating regularly around the mine site haul roads. Significant wind-borne dust was encountered during the inspection of the store yard area (see Section 10.1), however MRM staff called the water truck to come and dampen down the area.

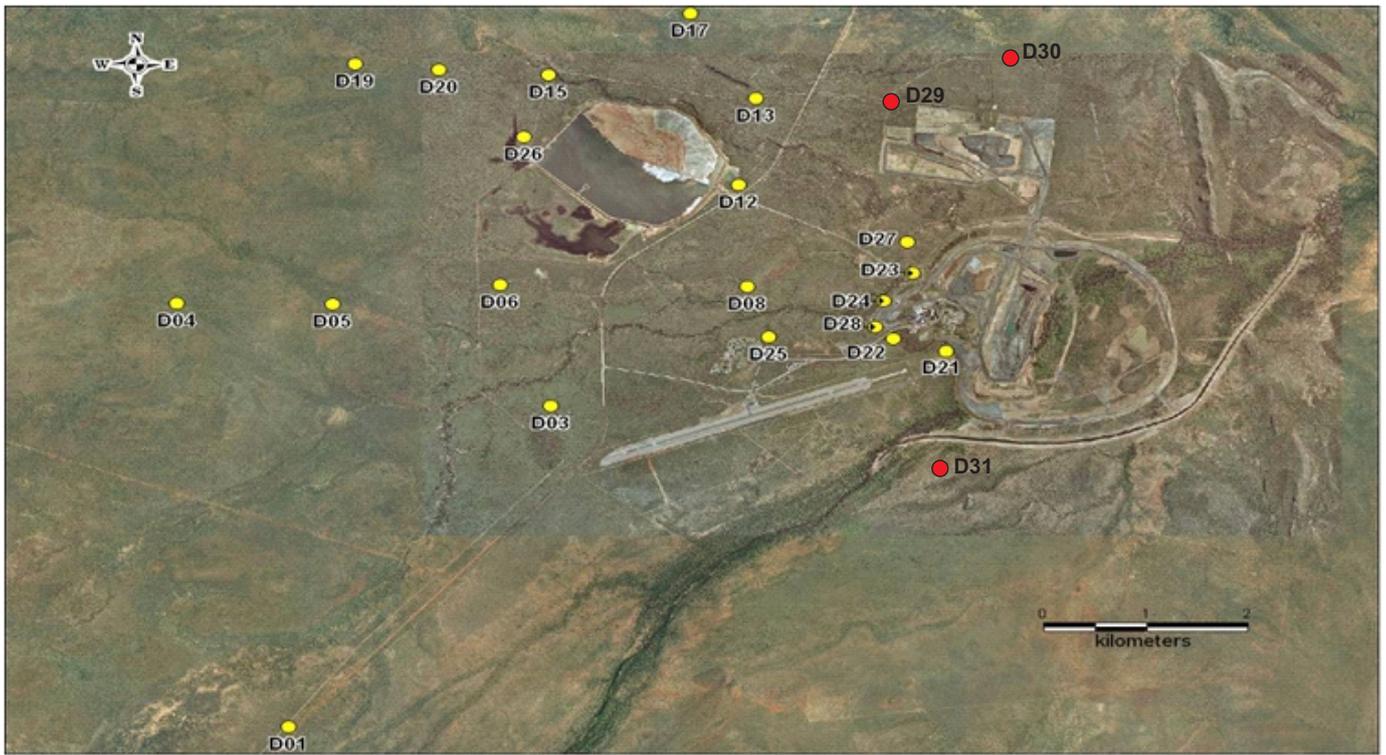
#### *Bing Bong Port Facility*

At the Bing Bong Port Facility contaminated dust issues are primarily associated with the concentrate storage shed. Because the shed doors must be kept open to prevent gas build-up, the prevailing winds can pick up dust from within the shed and transport it to the surrounding landscape and marine waters/sediments (Plate 9). Further, the condition of the corrugated iron shed walls was observed to be still poor in many places, with many small holes allowing the potential escape of concentrate dust. These issues have been identified by the Independent Monitor in past years.

During the inspection, MRM advised that capital expenditures to upgrade the shed have now been approved. These upgrades will include a shed ventilation system which will allow the shed doors to be kept shut. The IM looks forward to seeing these improvements next audit.

The additional dust gauge (BB6), which is located on the mud flats (Figure 5), up-wind of the Bing Bong Facility was sighted during the site inspection. It is acknowledged that this gauge was added by MRM in response to a recommendation by the Independent Monitor in the previous audit report.

The Aburri barge was being loaded at the time of the inspection and no dust was seen emanating from the conveyor system or visible anywhere on the surrounding paved surfaces. Please see section 10.3.1 for further details on observations made during the loading procedure.



Source: MRM Water Management Plan 2010/2011



Source: MRM Water Management Plan 2010/2011

- New monitoring locations
- Existing monitoring locations



	Title: Dust sampling locations at the Mine site (top) and Bing Bong Port (below)	
	Location: <b>McArthur River Mine, Northern Territory</b>	
Project: Independent Monitor 2010 Operational Period	Job No: 211011	
Project Man: <b>GM</b>	Scale: <b>As shown</b>	<b>Figure 5</b>
Drawn By: <b>PF</b>	Date: <b>August 2011</b>	



### 9.3.3 Dust monitoring program overview

According to the Environmental Monitoring Manual 2010, the dust monitoring program comprises fifteen depositional gauges located at the mine site (for example, see Plate 6) and six located at the Bing Bong Port loading facility. It is acknowledged that MRM has increased the number of locations in response to the Independent Monitor comments from the last audit as follows:

- two additional sites near the northern overburden emplacement facility;
- one new site south of the McArthur River channel. Based on its location, some sampling occurrences maybe missed during the wet season; and
- one additional site to the west of the swing basin on the tidal flat. Based on its location some sampling occurrences may be missed due to tidal movements.

The gauges are to remain in place for a period of  $30 \pm 2$  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.



**Plate 6** Depositional dust monitoring location. Source: Independent Monitor.

As noted by MRM in the MMP, dust levels are generally directly associated with the prevailing wind direction, which is north-west, and dust levels are characteristically higher during the dry season due to the lack of natural soil wetting over this period.



**Plate 7** Likely concentrate dust accumulating on objects in the PACRIM yard



**Plate 8** Sprays located at the top of the conveyor are now used more often.



### 9.3.4 Review of dust monitoring program reporting

The results of the dust monitoring program for the 2010 operational period are reported in section 4.2.9.1 of the Sustainable Development Mining Management Plan (MMP) 2010/2011.

Compared with previous years, MRM has shown some improvement in their reporting of dust monitoring results; namely the inclusion of dust analyte concentration charts and discussion of results for selected monitoring locations, however many more improvements are still needed.

With respect to the dust monitoring program, we make the following observations of major concerns:

- the level and detail in reporting on dust monitoring does not meet best practice industry standards, and does not display adequate scientific method. In general, we do not consider the level and detail of reporting in the MMP alone to be of an adequate level to effectively identify:
  - sources of dust generation;
  - effectiveness of dust mitigation measures;
  - temporal trends in dust generation or concentrations of contaminants in dust; or
  - methods for further improvements to the dust management program;
- there are a number of errors in the data analysis provided in the MMP. Further, greater detail in discussions of temporal trends analyses and improvement in validity of data evaluation methods are still required—this is discussed further in section 9.3.5;
- no trigger levels or positive objectives for dust reduction have been applied to the dust monitoring program. The MMP simply states that the objective of the program is to “monitor potential contaminated particulate matter (dust particles) arising from MRM activities” (pg. 74). This objective is considered to be too vague to provide a meaningful basis or direction for a long-term scientific monitoring study.

Other observations include:

- the locations of the following dust monitoring sites are not provided in the Environmental Monitoring Manual Maps or MMP:
  - Bing Bong Port dust monitoring location BBD6—furthermore, no results were provided for this monitoring location and it is unclear whether it exists at all;
  - the new Bing Bong Port dust monitoring location (location later provided when requested);
  - two new gauges at the OEF locations (location later provided when requested); and
- the standard referred to in the Technical Manual for Environmental Monitoring (MRM, 2010b) needs to be updated from AS3580.1990-91 to Australian Standard AS/NZS 3580.10.1:2003.

### 9.3.5 Review of data supplied by MRM

The Independent Monitor has reviewed the dust monitoring data supplied by MRM in the MMP and makes the following observations with regard to dust and airborne lead and zinc levels:

- the MMP does not contain discussion of results or concentration charts for several locations including: PACRIM: D27, D22 and D21; and mine site locations: D04, D17, D06, D03, D20, D08, D25 and D05. It is unclear why these results are not reported. If



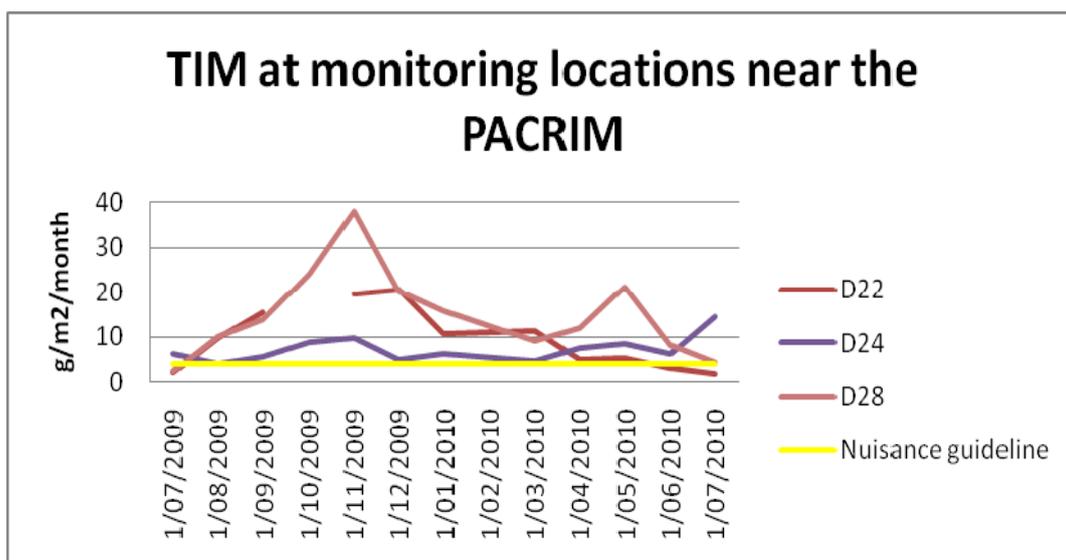
results are not reported because they are deemed to be low or not likely to pose an environmental hazard, then this should be clarified in the MMP for completeness.

- TIM levels were reported in the MMP in  $\text{g/m}^2$ ; but no timeframe is provided. These results should be reported as  $\text{g/m}^2/\text{month}$  or  $\text{mg/m}^2/\text{day}$ , which is preferred, as per Australian Standard AS/NZS 3580.10.1:2003;
- the use of line charts to present depositional dust and airborne metal results in the MMP, implies spatial interpolation; that is, that the actual depositional dust rate of airborne dust metal concentrations between two monitoring locations can be extrapolated from the graph. This is incorrect. Consequently, due to the fact that data is only true for that specific monitoring point, not other areas in between, we recommend that data be presented in bar charts in future reports;
- laboratory transcripts or internal results spreadsheets were not provided for monitoring locations D01 and D04—although the results for location D01 are mentioned in the MMP. When MRM were queried on this issue, Gary Taylor (pers. comm., June 2011) indicated that these locations are no longer being monitored, and that results discussed in the 2010/2011 MMP for D01 actually correspond to location D27. This information should be clearly recorded in the MMP or other supporting document;
- the number of times that the sampling gauges were not left for the correct number of days ( $30 \pm 2$ ) as required by Australian Standard AS/NZS 3580.10.1:2003 (Standards Australia, 2003), has decreased when compared to the previous year of monitoring. MRM have, therefore, improved their compliance in this respect and it is also understood that inclement weather/unsafe conditions may prevent MRM from achieving full compliance with this condition;
- dust levels and metals concentrations were presented in charts in the 2010/2011 MMP. Compared with previous years, the results do not indicate any noticeable decrease in either dust or metal concentrations in any of the locations reported;
- high lead concentrations and TIM levels were noted in locations close to and downwind of the PACRIM crushing plant—that is, dust monitoring locations D24 and D28. TIM levels at these locations ranged up to  $38 \text{ g/m}^2/\text{month}$ , with lead concentrations as high as  $45\,000 \text{ mg/kg}$  (4.5%). This supports the Independent Monitor's site observation that high levels of lead and zinc dust are emanating from the PACRIM crushing area and impacting the soil in the flood plain of a Barney Creek tributary;
- The Independent Monitor does *not* agree with MRM's statement that "there is little if any correlation between lead and zinc and total insoluble matter (TIM)", which was made in the 2010/2011 MMP. In fact, the Independent Monitor has determined a *strong* correlation through undertaking a linear regression analysis of TIM, lead, and zinc data supplied by MRM, having derived  $R^2$  values of 0.89—for mass of lead versus TIM—and 0.85—for mass of zinc versus TIM, which implies a very high degree of correlation. It is noted that MRM have not provided any evidence of having undertaken such statistical analysis of their data in the MMP, which is concerning; and
- although monitoring location BB1 at Bing Bong Port recorded dust lead concentrations of up to  $600\,000 \text{ mg/kg}$  (or 60%), the TIM at this location has decreased since the last monitoring period; this finding highlights the fact that, although total dust collected at this site may have decreased, the dust that was collected is contaminated with a high proportion of lead, which is likely to have originated from concentrate stored at Bing Bong Port (see Plate 9).

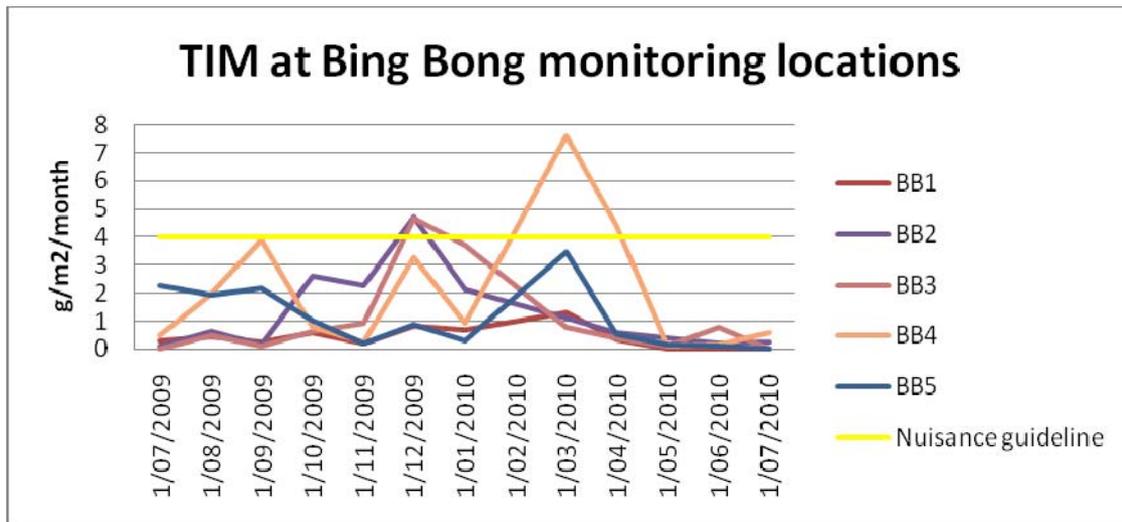


**Plate 9** Aerial photograph showing the position of the Bing Bong concentrate storage shed in relation to the prevailing North West wind direction. Photo: Independent Monitor 2011.

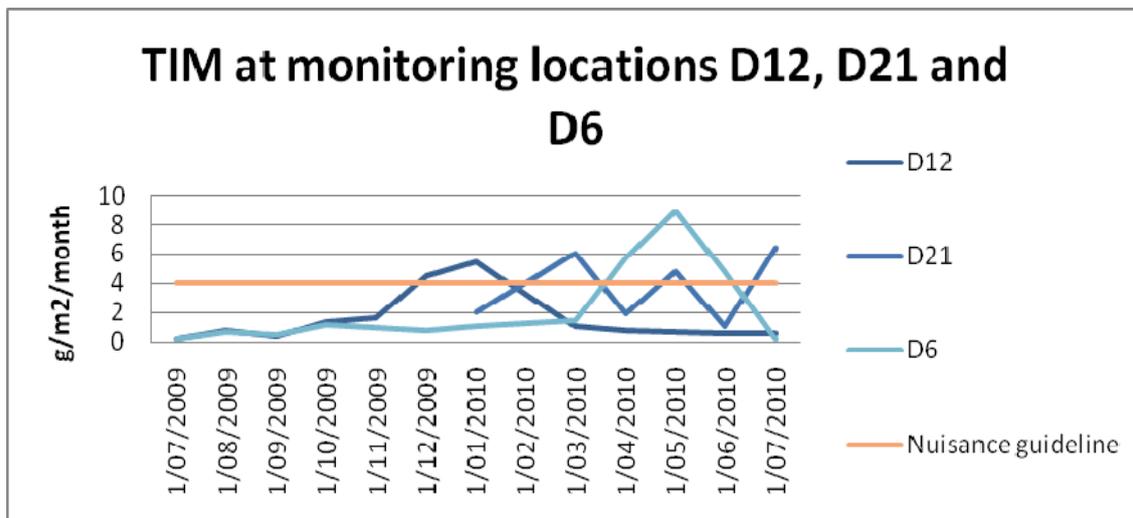
The Independent Monitor has also reviewed the raw dust monitoring data supplied by MRM, and provides Charts 1 to 3 showing TIM levels at selected locations—those with the highest TIM levels—in the mine site and Bing Bong Port. As no trigger levels are currently used by MRM to assess the dust results, the IM has applied “nuisance levels” (EDO, 2006) as a trigger guideline. It is also noted that, although not directly applicable to the mining operation, the nuisance level of 4 g/m<sup>2</sup>/month gives a general indication of dust levels at each monitoring location. This nuisance level corresponds to a “visible layer of dust deposited each month on outdoor furniture or on a clean car” (EDO, 2006).



**Chart 1** TIM at monitoring locations near the PACRIM.



**Chart 2** TIM at Bing Bong monitoring locations.



**Chart 3** TIM at Bing Bong monitoring locations D12, D21 and D6.

As can be seen in Charts 1 to 3, high dust levels (TIM) have been recorded at monitoring locations near the PACRIM: D22, D24 and D28 (see Figure 5 for locations). Elevated lead concentrations have also been recorded at these locations and it is therefore recommended that further mitigation measures should be implemented. In addition, elevated TIM levels may be an issue at monitoring location Bing Bong Port BB3, being the highest concentration over the nuisance level, and mine site D12, D21 and D6, being the highest concentrations at the mine site.

The Independent Monitor understands that, two monitoring seasons ago, the dust monitoring program changed from monitoring total solids (TS) to monitoring TIM in samples. These two values are not the same and cannot be compared. Therefore, dust monitoring data for only the two previous years of are available for comparison for TIM purposes. However, MRM should still be able to compare long-term temporal trends in heavy metal concentrations and total mass back further than two years ago.



**Plate 10** PACRIM area. Note fugitive dust in the centre of the photo. We note that MRM have advised that limiting dust emissions completely from this plant may not be possible. Photo: Independent Monitor 2011.

### 9.3.6 Bing Bong Dust Audit review, conducted March 2010

The Independent Monitor has reviewed the results of an audit of inhalable levels of metals/metalloids—arsenic, cadmium, lead and zinc—undertaken by MRM at the Bing Bong Port facility, the results of which are contained in the document Bing Bong Dust Audit (MRM, 2010a). Although the dust audit report focuses on dust as an occupational health issue, which is a matter outside the Independent Monitor’s audit scope, it nevertheless provides some additional information regarding dust levels and composition.

It is understood that MRM undertook an audit of inhalable dust metals at Bing Bong Port in March 2010. Inhalable metals were captured in institute of occupational medicine (IOM) inhalable dust samplers using eight Airchek 52 vacuum pumps, during concentrate loading. From the documentation supplied by MRM, the Independent Monitor understands that sampling was undertaken for 3.5 hours.

With regard to the Bing Bong Dust Audit report, the Independent Monitor makes the following observations:

- the sampling methodology, using IOM sample heads, and flow rate utilised (2 L/min) complies with Australian Standards AS 3640-2004 *Workplace atmospheres—Method for sampling and gravimetric determination of inhalable dust*, however, the report also mentions that the flow rates of each pump varied between 2016 L/hr and 2172 L/hr during the sampling period. This appears to be incorrect because we understand the IOM samplers used are incapable of such flow rates. It is thought that this may actually be referring to the total volume in litres of air that passed through the sampling equipment. The Australian Standard also requires detailed calibration of both the sample pump and micro balance, of which there are no details provided in the report.



These reporting errors and omissions further indicate a lack of scientific rigour as well as a lack of detail in reporting;

- from the documentation supplied to the Independent Monitor it is inferred that the sampling time was only for a period of approximately 3.5 hrs—that is, from “7:30 am to 11:15”, which we infer means 11:15 am—however, since the standard used is for workplace purposes, it is recommended that the sampling time correspond to the standard work shift—that is, 12 hrs—as well as being long enough to capture any diurnal changes in wind direction;
- the report quotes a laboratory limit of reporting (LOR) of 0.003 mg/m<sup>3</sup>, however all the results for arsenic and cadmium were reportedly <0.005 mg/m<sup>3</sup>, except for the West of Gantry E 1871 sample, which is reported as <0.006 mg/m<sup>3</sup>. It is unclear whether the LOR was raised to <0.005 mg/m<sup>3</sup> and <0.006 mg/m<sup>3</sup> or if this is an error in the report; and
- as with depositional dust monitoring, it is recommended that results be presented in bar charts so as to not imply spatial interpolation between sampling points.

A comparison of the reported results with the default thresholds indicated in the *Adopted National Exposure Standards For Atmospheric Contaminants In The Occupational Environment* (NOHSC:1003, 1995), shows all metal levels below the default guideline values, if an exposure of eight hours is considered, however, since it is understood from the MMP (MRM, 2010x) that staff works 12 hour shifts, the guideline thresholds need to be modified by a factor of 0.49 as per the Brief and Scala method recommended by Safework Australia (1995). Taking the 12 hour period into consideration, lead levels in samples West of Gantry E 1871 (0.086 mg/m<sup>3</sup>), Western ramp of shed E1872 (0.091 mg/m<sup>3</sup>), and Eastern ramp of the shed E 1883 are above the modified trigger value of 0.07 mg/m<sup>3</sup>.

It is strongly recommended that further mitigation measures be implemented at Bing Bong Port to reduce the levels of concentrate-bearing dust being released into the environment. It may also be useful to regularly undertake a similar dust audit to assess the effectiveness of mitigation measures and also to account for any seasonal variation of airborne metal levels, especially lead, that may not have been captured in this very short initial audit. Although the IM considers that the study does add additional information to the wider dust monitoring program regarding the potential sources of airborne dust and mitigation measures, the program would benefit from more detailed and accurate reporting in line with correct scientific method.

### 9.3.7 Simtars’ assessment review, November 2010

MRM commissioned Simtars to conduct a review of atmospheric and health issues at MRM, the results of this review are reported in the *Program Review of Atmospheric Monitoring & Health Surveillance at McArthur River Mine* report (Simtars, 2010). As with the Bing Bong Dust Audit report (2010), we note that this matter is an occupational health issue, but contains valuable information regarding the causes of fugitive dust at MRM and mitigation measures. The IM agrees with Simtars’ recommendations that MRM should:

- explore the use of different water sprays in the concentrate shed to continually keep the concentrate moist;
- where possible consider reducing concentrate stockpiles around the plant;
- use water trucks or water sprays to aid in dust suppression of worked stockpiles; and
- consider implementing an ongoing program to remove spilt concentrate from crushing plant and conveyors.



**Plate 11** Dust generated by working drill rig. Photo sourced from Simtars (2010) assessment



**Plate 12** Independent Monitor team outside of concentrate storage shed at Bing Bong Port facility.

Further, we agree with the key observations made in the Simtars report (2010), which have been provided below to highlight potential sources of dust generation. These observations include:

- due to lack of training of the operator, the dust suppression system on the working drill rig was not functioning (see Plate 11);
- fine dusts are present below the ejection chute of the mobile crushing plant and within the stockpiles of processed stone;
- concentrates of varying degree of moisture are stored in the shed (Plate 12). As concentrate dries out it increases the risk of fugitive dust emissions from the shed;



- dust generation is reduced by the use of water sprays in the primary crushing plant and conveyors, while a water truck is used to control dust from ore stockpiles. However, it was noted that this water rapidly evaporates due to the high ambient temperatures;
- spilt concentrate was observed in the conveyors and regrind area. This material can dry out and pose a dust generation risk; and
- concentrate stockpiled onsite, when the Bing Bong Port operations are halted, will quickly dry out and increase dust generation potential.

### 9.3.8 Conclusions and recommendations

Further efforts to control fugitive dust emissions are needed, particularly in the PACRIM area, where high TIM and lead concentrations have been recorded. The latter situation is the issue of most concern with regard to the dust monitoring program undertaken by MRM. This is due to the likely considerable contribution that concentrate-laden dust is having on sediment and soil metal enrichment. The IM also makes the following additional recommendations:

- MRM should work towards eliminating the issues identified in the Simtars' assessment by increasing concentrate moisture, reducing concentrate stockpiles, increasing the use of water sprays and water trucks, implementing a spilt concentrate recovery program and more effectively training MRM staff. It is also recommended that a similar assessment be undertaken annually;
- MRM should improve on reporting issues identified: provide laboratory QA/QC data, update maps and standards referred, improve the analysis of monitoring data, and so on. This should facilitate the identification of problematic areas and trends, and thus aid in the decision making process for implementing mitigation measures. It will also validate and impart greater robustness to the data collected;
- dust mitigation works should be commenced during the next reporting period, including: placing a vegetation barrier between the ROM pad and main road, implementing an extraction system in the concentrate shed and increased use of the street sweeper; and
- investigate the option of applying a commercially available dust stabilisation product to aid in dust mitigation. The Independent Monitor is aware of several products targeting different issues, such as road dust, stockpile dust and work generated dust; that may be useful to MRM. However, the use of these products needs careful assessment and planning to ensure they do not affect the surrounding environment. At the very least, the product to be utilised should comply with Australian and international standards for biodegradability.

## 9.4 Review of soil monitoring

### 9.4.1 Soil monitoring program overview

According to the Environmental Monitoring Manual 2010, 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 analyses (PSA).

The soil monitoring sampling locations are presented in Figure 6.