6.0 Waste Management

6.1 Summary

This section address the following issues raised in the PER guidelines:

- *Measures to prevent the mobilisation of contaminants from overburden which has been used in mine structures from entering the McArthur River.*

  Only competent non-acid-forming (NAF) material will be used on the external faces of mine structures (overburden emplacement facility, flood protection bund, and tailings storage facility) from which runoff could drain to the McArthur River. Extensive testing has been used to identify all overburden materials that are NAF and hence will not generate contaminated runoff. As a further precaution, runoff from these structures will pass through sediment ponds prior to discharge. This discharge will be monitored to ensure that it will have no deleterious effects in the McArthur River.

- *Undertake kinetic leach testing of overburden materials.*

  Long-term kinetic column leach testing has been underway (and is continuing) for a range of composite samples of waste rock materials in on-site columns and laboratory columns for approximately three years. In addition, a new round of kinetic leach testing commenced in April 2006 for individual waste rock materials that previously were not subject to kinetic leach tests and also for replicates of some previously tested materials. Initial results from the recent testing have confirmed the overburden characterisation based on the initial testing and reported in the Draft EIS (URS, 2005a). The testing results have shown that the NAF materials (with the possible exception of the NAF Upper Pyritic Shale) will not generate runoff containing metals in excess of guideline values. The kinetic testing will continue to ensure that this situation does not change over time.

- *Provide a risk management strategy and contingency options if NAF runoff is found to be a source of contamination.*

  If monitoring shows that sediment pond discharge exceeds agreed trigger levels, a risk assessment will be undertaken to quantify the risk of the NAF runoff metals load on downstream aquatic ecosystems. If the risk assessment identifies potential for adverse effects, corrective actions will be implemented. These actions could include increasing the capacity of the sediment ponds to reduce the quantity of pond discharge and increase effectiveness of sediment settling rates, or pumping water from the sediment ponds to the TSF water management dam for re-use in the processing plant.

6.2 Measures to Prevent Mobilisation of Contaminants

This sub-section describes how the water and materials management systems at McArthur River mine have been designed to ensure that the risk of mobilisation of contaminants is minimised from the overburden emplacement facility (OEF) and from NAF material used in the construction of the flood protection bund and the tailings storage facility (TSF).

6.2.1 Overburden Emplacement Facility

Overburden from the open cut has been geochemically tested to classify it as either PAF or NAF. The PAF overburden has the potential, in the presence of air and water, to generate acidic water, soluble metals and salts that could impact the environment. NAF overburden is chemically stable with low potential for generation of environmentally significant products.

The available overburden characterisation data indicate that up to 11% of the total overburden could be PAF.

In the OEF, PAF overburden will be encapsulated within clay cells and layers of NAF waste in the western zone of the OEF to prevent the ingress of air and water to ensure that there is no acidic seepage generated. NAF overburden only will be placed in the eastern zone of the OEF.

All surface and seepage flows from the western zone of the OEF will report to a PAF pond which will be designed to have a 1 in 100 Annual Exceedance Probability (AEP) of spilling. It will also be designed to exclude a 1 in 100-year average recurrence interval (ARI) flood event. Water contained in the pond will be pumped to the water management dam at the TSF for reuse in the processing plant. This water will not be discharged off site and hence will not enter the McArthur River system.

All surface and seepage flows from the eastern zone of the OEF will report to a sediment pond which will be designed to contain up to 50 mm of average erosion depth from the contributing catchment (approximately 1,000 t/ha/year). As there will be no PAF in the eastern zone, the only potential contaminant in the runoff will be NAF sediment. The sediment pond will primarily function as a flow-through structure designed to remove the majority of sediment load in the runoff prior to discharge to downstream drainage. There will be three sediment ponds constructed for the various stages of the eastern zone construction.

The quality of overflows from the NAF sediment ponds will be monitored as part of the site-wide surface water monitoring program. The water and sediment monitoring program that will initially be implemented for potential contaminants mobilised from overburden mine materials is outlined in Section 8.4. The monitoring program will continue to evolve as mining develops, to evaluate and minimise the risks of contaminants from mining operations entering the McArthur River.

The proposed contingency measures to be implemented in the event that the monitoring program indicates contamination in the NAF sediment ponds are discussed in Section 6.4.

6.2.2 Flood Protection Bund and Tailings Storage Facility

The flood protection bund and the embankment of the TSF will be constructed using NAF overburden so that the risk of mobilisation of contaminants and their discharge to the McArthur River is minimised. PAF material will not be used.

As discussed in Section 8.2.3, the external face of the flood protection bund will be rock-filled to protect its internal clay core against erosion and to provide geotechnical stability in accordance with relevant engineering standards (Section 9.2).

Initially the rock-fill material will be a combination of the Breccias and Dolomitic Sandstone excavated from the river diversion channel. Subsequently the slope of the internal and external faces of the bund will be reduced by the addition of more rock-fill by using NAF competent rocks from the mine pit. Runoff from the external face of the flood protection bund will be channelled using contoured drainage to sediment ponds prior to being discharged.

The TSF embankment will be designed as a water retention structure in a similar manner to the flood protection bund. It will consist of a low permeability clay core which will be keyed into the underlying foundation material. The clay core will be covered with a rock-fill embankment to enhance its structural integrity and to provide erosion protection. Rock will be sourced from the river diversion excavation and from mine pit overburden. Only competent NAF rock will be used. Runoff from the external face of the embankment will be channelled using contoured drainage to sediment ponds prior to being discharged.

These proposed preventative strategies will provide a triple level of protection by ensuring that:

- Only competent NAF materials that do not leach metals and salts at bio-available concentrations exceeding ANZECC criteria will be exposed
- The embankment's clay core will be protected by a rock-fill face of competent NAF material to prevent erosion of the core from both direct rainfall runoff and flooding
- Runoff from the external face of both structures will pass through sediment ponds to retain any sediment which might be generated. After two years of monitoring the quality of water discharged from the sediment ponds, the need for their ongoing operation will be reviewed in consultation with the Northern Territory government.

6.3 Kinetic Leach Test Results

Long-term kinetic column leach testing has been underway (and is continuing) for a range of composite samples of waste rock materials in on-site columns and laboratory columns for approximately three years. In addition, a new round of kinetic leach testing commenced in April 2006 for individual waste rock materials that previously were not subject to kinetic leach tests and also for replicates of some previously tested PAF and NAF materials. A summary of the analytical results to date is given in Table 6.1. The complete results of all kinetic leach column tests to date are given in Appendix H.

The kinetic leach testing of composite NAF Lower Pyritic Shale (which includes NAF Bituminous Shale) and Dolomitic Shale material reported in the Draft EIS (URS, 2005a) indicated that these materials may be marginally elevated with respect to sulfate only (relative to ANZECC (2000a) and NEPM (1999) livestock drinking water guidelines). These results have been confirmed by the recent testing of the individual materials. The leachate collected from NAF Bituminous Shale, NAF Lower Pyritic Shale and Lower Dolomitic Shale is pH neural and fresh to brackish. Sulfate marginally exceeds applied guideline criteria in NAF Bituminous Shale only.

Kinetic leach column testing of individual samples of the NAF materials including W-fold Shales, Teena Dolomite, Dolomitic Sandstone, and Breccia began in April 2006. Early-stage results indicate that leachate from these materials will be pH neutral, fresh and have concentrations of metals and salts below

ANZECC (2000a) and NEPM (1999) livestock drinking water guidelines. This confirms the leach test results from the composite samples that began in 2003 and was reported in the Draft EIS (URS, 2005a).

Kinetic leach tests results from the recently commenced testing program indicate that the NAF Upper Pyritic Shale may initially leach levels of metals and salts (Al, Cd, Co, Ni, SO_4, Se and Zn) at concentrations that could exceed the ANZECC (2000a) and NEPM (1999) livestock drinking water values. The low pH value associated with the first flush event (pH 4.4) was not expected; the pH of the second flush was less acidic (pH 5.65) and more typical of NAF material. It is expected that longer-term leaching of this column will produce results that are more consistent with the second flush results. Previous long-term testing of NAF Upper Pyritic material (mixed with Dolomitic Shale) produced leachate that was pH neutral and fresh to brackish with sulfate and selenium marginally exceeding relevant guideline criteria. Because of the doubt over the quality of the runoff from this NAF material and due to its low durability, the NAF Upper Pyritic Shale will not be used on the external faces of the OEF, flood protection bund or the TSF.

The testing results have confirmed that the NAF materials (with the possible exception of the NAF Upper Pyritic Shale) will not generate runoff containing metals in excess of guideline values. The kinetic testing of these materials will continue to ensure that this situation does not change over time.

On this basis, there will be a low risk of metal mobilisation from the use of these NAF materials. However, to be suitable for use in the outer layers of the OEF or for construction of the flood protection bund and the TSF embankment, the NAF material will also need to be hard and durable so that it will not breakdown and erode over time. The most suitable NAF materials in this respect are the weathered sandstone, Teena Dolomite, Dolomitic Sandstone and Breccia. These materials will be used on the exposed surfaces of the OEF, TSF and flood protection bund. The NAF pyritic and bituminous shales are less durable and are not considered to be suitable for external use.

Table 6.1
Summary of Kinetic Leach Column Testing of Rock Materials

Column ID	Rock Materials	Start Date	Finish Date	Acid * Generation Classification	Summary results to date (Refer to Appendix H for details)
TP4/6-12	Highly weathered siltstone (alluvium) from 6-12 m depth	Feb 06	*ongoing*	NAF	pH neutral and stable, EC fresh to slightly brackish, no elements exceed applied guideline values.
TP4/13-18	Partially weathered/fresh siltstone (alluvium) from 13-18m depth	Feb 06	*ongoing*	PAF	pH neutral, EC slightly brackish, Cd and Pb generally above and SO_4 intermittently above applied guideline values.
PER 1	NAF Upper Pyritic Shale	April 06	*ongoing*	NAF	Three flush results only: pH initially acidic (pH 4.4) but increases to neutral (pH 5.65 & 5.3), EC is saline, Al, Co, SO_4 and Se above applied guideline values in first flush; SO_4, and Se above applied guideline values in subsequent flushes.
PER 2	PAF Upper Pyritic Shale	April 06	*ongoing*	PAF	Three flush results only: acidic (pH 3.7 to 4.6), saline (average 15,400 µS/cm), Al, Cd, Co, SO_4 and Se above applied guideline values in first flush; SO_4, and Se above applied guideline values in subsequent flushes.
PER 3	NAF Bituminous Shale [1]	April 06	*ongoing*	NAF	Three flush results only: pH neutral (Avg. pH 6.7), EC brackish, SO_4, and intermittently Se, above applied guideline values.
PER 4	PAF Bituminous Shale	April 06	*ongoing*	PAF	Three flush results only: pH neutral (Avg. pH 6.7), EC brackish to saline, SO_4 above applied guideline value.
PER 5	NAF Lower Pyritic Shale	April 06	*ongoing*	NAF	Three flush results only: pH neutral (Avg. pH 7.1), EC fresh to brackish, no elements exceed applied guideline values.
PER 6	PAF Lower Pyritic Shale	April 06	*ongoing*	PAF	Three flush results only: pH neutral (Avg. pH 7.1), EC slightly brackish, SO_4 intermittently exceed applied guideline value.
PER 7	Lower Dolomitic Shale	April 06	*ongoing*	NAF	Three flush results only: pH neutral (Avg. pH 7.1), EC slightly brackish, Se intermittently exceed applied guideline value.
PER 8	W-Fold Shale	April 06	*ongoing*	NAF	Three flush results only: pH neutral (Avg. pH 7.5), EC fresh, no elements exceed applied guideline values.

Column ID	Rock Materials	Start Date	Finish Date	Acid * Generation Classification	Summary results to date (Refer to Appendix H for details)
PER 9	Teena Dolomite	April 06	*ongoing*	NAF	Three flush results only: pH slightly alkaline (Avg. pH 8.0), EC fresh, no elements exceed applied guideline values.
PER 10	Dolomitic Sandstone	April 06	*ongoing*	NAF	Three flush results only: pH slightly alkaline (Avg. pH 8.0), EC fresh, no elements exceed applied guideline values.
PER 11	Breccia	April 06	*ongoing*	NAF	Three flush results only: pH slightly alkaline (Avg. pH 8.1), EC fresh, no elements exceed applied guideline values.
Lab 1	PAF Lower Pyritic/Dolomitic Shale	Jan 03	*ongoing*	PAF	pH decrease from 7 to 3.2, EC increase from brackish to saline, SO_4 and most heavy metals concentrations above applied guideline values.
Lab 2	PAF Upper Pyritic/Dolomitic Shale	Jan 03	June 04	PAF	Column discontinued
Lab 3	NAF Lower Pyritic/Dolomitic Shale	Jan 03	June 04	NAF	Column discontinued
Lab 4	NAF Upper Pyritic/Dolomitic Shale	Jan 03	*ongoing*	NAF	pH neutral and stable, EC fresh to brackish, Se intermittently marginally above applied guideline values.
Lab 5	AC Cooley Dolomite and PAF Lower Pyritic/Dolomitic Shale and AC W-fold Shale (3:3:3 ratio of each)	Jan 03	*ongoing*	NAF	pH decreased from 8 to ~5.7, EC brackish, Cd, Zn and SO_4 above applied guideline values.
Lab 6	AC Cooley Dolomite and PAF Upper Pyritic/Dolomitic Shale and AC W-fold Shale (3:3:3 ratio of each)	Jan 03	*ongoing*	NAF	pH neutral and stable, slight EC increase, Cd, Zn and SO_4 periodically above applied guideline values.
Lab 7	AC Cooley Dolomite & PAF Lower Pyritic/Dolomitic Shale and AC W-fold Shale (1:5:3 ratio of each)	Jan 03	June 04	NAF	Column discontinued

Column ID	Rock Materials	Start Date	Finish Date	Acid * Generation Classification	Summary results to date (Refer to Appendix H for details)
Lab 8	AC W-fold Shale & PAF Lower Pyritic/Dolomitic Shale and AC Cooley Dolomite (1:5:3 ratio of each)	Jan 03	June 04	NAF	Column discontinued
Site 1	PAF Lower Pyritic/Dolomitic Shale	Jan 03	Feb 04	PAF	Column discontinued
Site 2	PAF Lower Pyritic/Dolomitic Shale	Jan 03	*ongoing*	PAF	pH generally 2 - 4.5, EC sporadic, Cd, Zn and SO_4 generally above applied guideline values.
Site 3	NAF Lower Pyritic/Dolomitic Shale	Jan 03	Feb 04	NAF	Column discontinued
Site 4	NAF Lower Pyritic/Dolomitic Shale	Jan 03	*ongoing*	NAF	pH neutral and stable, EC brackish but variable, SO_4 generally above applied guideline values.
Site 5	PAF Upper Pyritic/Dolomitic Shale	Jan 03	Feb 04	PAF	Column discontinued
Site 6	PAF Upper Pyritic/Dolomitic Shale	Jan 03	*ongoing*	PAF	pH decrease from 7.3 to 3.5, EC brackish but variable, Cd, Zn and SO_4 generally above applied guideline values.
Site 7	NAF Upper Pyritic/Dolomitic Shale	Jan 03	*ongoing*	NAF	pH neutral and stable, EC brackish, Se and SO_4 periodically above applied guideline values.
Site 8	NAF Upper Pyritic/Dolomitic Shale	Jan 03	Feb 04	NAF	Column discontinued
Site 9	AC Cooley Dolomite and PAF Lower Pyritic/Dolomitic Shale and AC W-fold Shale (3:3:3 ratio of each)	Jan 03	*ongoing*	NAF	pH decrease from 7.3 to 4, EC sporadic, Cd, Zn and SO_4 generally above applied guideline values.
Site 10	AC Cooley Dolomite and PAF Upper Pyritic/Dolomitic Shale and AC W-fold Shale (3:3:3 ratio of each)	Jan 03	*ongoing*	NAF	pH neutral, EC brackish, Cd and SO_4 generally above applied guideline values.

Column ID	Rock Materials	Start Date	Finish Date	Acid * Generation Classification	Summary results to date (Refer to Appendix H for details)
Site 11	AC Cooley Dolomite & PAF Lower Pyritic/Dolomitic Shale and AC W-fold Shale (1:5:3 ratio of each)	Jan 03	Feb 04	PAF	Column discontinued
Site 12	AC W-fold Shale & PAF Upper Pyritic/Dolomitic Shale and AC Cooley Dolomite (1:5:3 ratio of each)	Jan 03	Feb 04	NAF	Column discontinued

* AC = Acid Consuming; NAF = Non Acid Forming; PAF = Potentially Acid Forming.

[1] NAF Lower Pyritic Shales in Lab and Site experiments (Lab 1 – 8, Site 1-12) include Bituminous Shales

6.4 Risk Management Strategy

6.4.1 Trigger Levels and Corrective Actions

As discussed in Section 6.2, NAF material to be used for the TSF, flood protection bund and external face of the OEF is expected to generate non-acidic runoff with metal and salt concentrations below ANZECC (2000a) and NEPM (1999) livestock drinking water guidelines. Nevertheless, it is proposed that this runoff will be collected in sediment ponds.

The sediment ponds will occasionally overflow clean runoff water into receiving waters. The quality of overflow water will be monitored as described in Section 8.4.

Trigger levels will be established to determine if the quality of overflow waters is a potential risk to aquatic ecosystems in accordance with the following criteria:

- If filtered metals concentrations in NAF sediment pond overflow exceed hardness-modified trigger values metals criteria for 95% protection level of freshwater aquatic ecosystems; or
- If total metals in NAF pond overflow exceed corresponding total metals concentrations in upstream McArthur River by more than 10%.

If monitoring shows that either of the above trigger levels is exceeded, one or more of the following corrective actions and safeguards will be implemented:

- Risk assessment studies will be undertaken to quantify the risk of NAF sediment pond metals load on the downstream aquatic environment. This will involve the determination of:
  - The total quantity of metals in the NAF sediment pond discharge (by integration of discharge quantity and metals concentration) to evaluate total metals loads into the McArthur River
  - The total upstream McArthur River metals load.
- The relative impact of the sediment pond metals load on McArthur River metals load will be determined to quantify the risk of the NAF sediment pond metals load on downstream aquatic ecosystems. The assessment process and results will be undertaken in consultation with the Northern Territory Government.
- If the risk assessment identifies potential for adverse risk to downstream aquatic ecosystems from the sediment pond discharge, corrective actions will be implemented which could include:
  - Increasing the capacity of the NAF sediment ponds to reduce the quantity of pond discharge and increase effectiveness of sediment settling rates; or
  - Pumping water from the NAF sediment ponds to the water management dam at the TSF to minimise the probability of discharge and re-evaluating the site water balance modelling to quantify the impact on overflow risk of the TSF. If necessary, the capacity of the TSF will be increased to maintain its design criterion of 1 in 500-year overflow risk.

6.4.2 Sampling and Analysis Constraints

Necessary safety controls for environmental monitoring activities could be a potential hindrance to sampling of NAF runoff contained in sediment ponds during or following heavy rainfall. However the revised design (Barney Creek bridge crossing) and provision of maintained access tracks to the NAF sediment ponds will ensure that access for sampling can be safely provided in the majority of rainfall events (excepting flooding conditions). As an added safeguard to determine the need for contingency containment, if sampling during rainfall events is not possible, routine water quality monitoring data (weekly sampling of ponds whenever water is present) will be available to provide water quality data for NAF sediment ponds to allow informed decision.

MRM will have on-site laboratory facilities for rapid analysis of metals concentrations in water and sediment. This will enable assessment of samples in less than 24 hours by which time decisions can be made regarding the need for contingency actions.

6.4.3 Containment Contingencies and Response Times

MRM will provide resources required to facilitate rapid response for contingency containment of NAF runoff water. Pipelines will be installed and standby pumps will be available for pumping NAF runoff water to the site's contained water management system if necessary. With readily available resources, contingency pumping can be initiated in less than 24 hours if necessary.

Regular updates of the OPSIM water balance modeling will be used to monitor and maintain the overflow risk of the PAF Pond and TSF water management dam. If necessary, the PAF pond capacity could be enlarged based on OPSIM water balance modeling reviews to maintain the 1 in 100-year containment criterion (overflow risk). Additional NAF runoff storage containment can also be provided. Clean clay and rock would be available in the NAF zone of the OEF to enable construction of additional temporary sediment ponds if required. These additional storage containment strategies can be rapidly implemented if necessary.

These containment contingencies provide an added level of protection. The optimum containment requirements will be determined within the first 2 years of operations based on the monitoring outlined in Sections 6.4.1 and 8.4.

6.4.4 Start-up Monitoring and Impacts

For the initial project start-up, several rainfall events will be required to gain accurate and best possible information of the actual NAF runoff quality and actual quality of discharge from the NAF sediment ponds. There will be minimal potential for adverse impact from this early project period. The start-up period will be short (in the context of time periods of concern for on-going bio-accumulation of metals in aquatic biota) and the few isolated "pilot" storm events are to be expected to be clean relative to ANZECC HMTV metals concentration criterion and natural McArthur River water quality. Slight deviances from these criteria (eg. 25%) in a few isolated discharge events early in the start-up period while adjustments are made to containment contingency strategies will not be sufficient to cause impact of on-going bio-accumulation of metals in aquatic biota (i.e. persistent discharge of excessive metals concentrations would be required for bio-accumulation to occur).

MRM has committed to making available the necessary resources and implementing the works required to ensure that the containment strategy for NAF runoff achieves the target criteria within the first two years. With the best possible information at this stage of the project, it is expected that NAF runoff will be sufficiently clean from the commencement of the project and these additional commitments are considered as added safeguards.