McArthur River Open Cut Mine Expansion:
Public Environmental Report –
Review of seepage issues related to the Tailings Storage Facility

Prepared for: NT Environment Protection Agency Program (NRETA)
Prepared by: EWL Sciences Pty Ltd

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Date: August 2006

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Author: A Puhalovich

Date: August 2006

Project Manager: ____________________
Alan Puhalovich

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EXECUTIVE SUMMARY

Project Focus

EWL Sciences has been commissioned to provide a critical evaluation of the adequacy of information included in the Public Environmental Report (PER) for the McArthur River Mine Open Cut Project with respect to the proposed tailings storage facility, including the adequacy of proposed management and mitigation options. The evaluation focussed on the critical issue of potential for contamination in the longer term (>30 years) and impacts to the environment.

Approach

The approach followed in the review was to assess the adequacy of information presented in the context of historic seepages that have occurred from the existing TSF, the methods used to select the preferred seepage management/mitigation option and predictive modelling. The information was then 'benchmarked' against available guidelines to determine whether the TSF design (in terms of the seepage management strategy) is appropriate.

Conclusions

1. The impacts of historic and current seepage from the existing TSF are not fully understood and the legacy issues related to this seepage (future impacts to receiving waters) have not been modelled;

2. There has not been an assessment of alternative, more appropriate TSF sites that would not contain permeable alluvial soils, that in turn would limit seepage from the TSF and hence reduce environmental risk;

3. It is unlikely that the TSF design would be approved in other states, based on available guidelines.

4. During the period of mine operations, contaminated groundwater from the seepage recovery bores may be pumped back to the TSF in the dry season. This could cause a long-term deterioration of seepage water quality, thus extending the time for seepage recovery

5. Post-closure, the TSF would not be self-sustainable and therefore does not meet ANCOLD (1999) guidelines.

6. In the unlikely event that MRM were placed into receivership before or at the end of mine operations, the NT Government would be left with a very substantial environmental liability that would require ongoing, costly management for a period of decades.

Recommendations

It is recommended that other designs for the TSF are developed and assessed with the prime objectives of limiting seepages to the underlying groundwater system (in the first place) and achieving compliance with relevant guidelines and standards for the operational and post-closure management of TSFs.

1. TERMS OF REFERENCE

The terms of reference for this review are listed below.

1. Critically evaluate the adequacy of information included in the Public Environmental Report for the McArthur River Mine Open Cut Project with respect to the proposed tailings storage facility, including the adequacy of proposed management and mitigation options presented in the Public Environmental Report (PER).

2. Critical evaluation should focus specifically on the potential for contamination in the longer term (>30 years) resulting from seepage from the Tailings facility. The proponent was asked to undertake modelling for the proposed tailings storage facility to account for best- and worst-case scenarios into the long term (>30 years) to determine the risk of these scenarios occurring and the predicted probable environmental impact. Management options were requested to be presented in the PER to minimise the risk of these adverse environmental impacts occurring.

3. Assist in the development of recommendations for inclusion in the final Assessment Report (the presentation of the findings of the assessment undertaken by the EPA Program) on the acceptability of predicted impacts, proposed management measures and proposed monitoring and mitigation programs outlined in the PER.

2. ADEQUACY OF INFORMATION ON THE TSF

The adequacy of the information in the PER was initially assessed in terms of the description of risks, identification of seepage management options and ultimately selection of the preferred management and seepage mitigation strategy.

A request for additional information, to assist with assessment of the above, was provided NRETA/EPA on 26 July 2006. This request was subsequently passed on to MRM on 31 July 2006 in a letter from the Minister for Natural Resources, Environment and Heritage to the General Manager – MRM. (Appendix A).

A response to the request for additional information was issued on 14 August 2006 (URS, 2006).

2.1 GUIDANCE

In the context of seepage issues related to the TSF, the PER Guidelines provided the following direction to environmental reporting, Section 4.7.2 in Assessment Report 51:

"EIS respondents recommended that the impact of various future scenarios, for a time period greater than 30 years (best to worse) should be modelled and asked that the risk of these scenarios occurring and the resultant environmental impacts associated with these scenarios be predicted. Further, management options for minimisation of the risk of these adverse environmental impacts occurring were requested by NRETA. The proponent has undertaken modelling for best- and worst-case scenarios for the TSF to 25 years, that is, during the expected mine life. No further modelling into the longer term has been presented except to estimate how long the recovery bore network may need to operate to ensure no further surface expression of seepage water would occur. ***The EIS should have provided modelling of the proposed tailings storage facility to account for best-and worst-case scenarios into the long term (>30 years) to determine the risk of these scenarios***

occurring and the predicted probable environmental impact. Management options for minimization of the risks of these adverse environmental impacts occurring should have been presented."

2.2 ENVIRONMENTAL REPORTING

The approach to the review of seepage issues associated with the TSF component of the MacArthur River PER was made with reference to key standards for long-term environmental management and closure planning at mine sites.

The responses in the PER that relate to our guidance (Section 0) are listed below.

PER July 2006 Volume 1 Main Report	
Section 7 Tailings Storage Facility	TSF information
Section 10 Groundwater	
PER July 2006 Volume 2 Appendices	
Appendix A Government Requirements	compliance
Appendix N Tailings Storage Facility Seepage Modelling Report	environmental risk/impact assessment
URS (2006) McArthur River Mine Open Cut Project PER: Response to Further Information Request (14 August 2006)	

2.3 HISTORIC PERFORMANCE OF EXISTING TSF

2.3.1 *Geological & Hydrogeological Conditions*

The existing TSF (Cell 1) contains tailings placed in direct contact with floodplain soils (shallow colluvial outwash fan deposits and alluvium). The majority of the upper sediments (soils) contain a mix of silt, sand and gravel, with the basal few metres containing permeable sand and gravel deposits. According to the Draft EIS, *"…the footprint of TSF contained significant areas where the surface soils comprised "permeable sands and gravels"*. The Draft EIS reports that the upper silts, clays and fine-grained sands have permeabilities of 2 m/day, while the lower coarse-grained sands, gravels and cobbles/boulders have permeabilities of 50 m/day. Aquifers exist in the alluvial soils.

The soils overlie weathered, dolomitic siltstone rocks. According to the Draft EIS, *"Groundwater can occur in open vugs or solution channels, fractures, joints and faults within the fresh bedrock*." It also states that *"…Furthermore, in situ testing within the underlying weathered dolomitic siltstone indicated that the siltstone was relatively permeable and contain karst features"*. Aquifers are known to exist within the dolomitic siltstone rocks.

Groundwater levels indicate easterly flow of groundwater from higher elevations near the TSF (up to RL 42 m) to lower elevations near the McArthur River (down to RL 20 m).

2.3.2 *Seepage Issues*

A seepage limiting layer (containment) underlying the tailings, such as a low permeability compacted clay or synthetic liner, is not utilised. Seepage from the existing TSF has been much greater than expected, with seepage of contaminated waters to Surprise Creek observed in June 1997. A geopolymer barrier to limit seepages to the creek was constructed along the wall (around the perimeter of Cell 1 fronting Surprise Creek) in 2005.

The Draft EIS states that salinity levels and sulfate concentrations are greater than those recommended in relevant ANZECC (2000a) guidelines. Some metal concentrations (Cd, Cu, Fe, Mn, Pb and Zn) in seepage/groundwater can be greater than ANZECC (2000a) water quality guideline criteria for fresh water ecosystems. According to URS (2006), groundwater quality data indicate that the pH of groundwater at the existing TSF is near neutral. Interestingly, comparisons of the above parameters were made against criteria for fresh water ecosystems in the Draft EIS, whereas URS (2006) compares data against livestock water quality criteria which are less stringent.

Trends in sulfate concentrations, for groundwater at the TSF (Figure 4.4 URS, 2006), show that sulfate concentrations for all groundwater bores were less than or equal to the livestock guideline value of 2,000 mg/L in late 1997/early 1998. By mid 2005, sulfate concentrations were all above the guideline value except for groundwater at GW7.

Groundwater monitoring data are limited and are mostly located near the perimeter of the existing TSF. The locations of existing plumes beyond the TSF are not known, particularly north of Surprise Creek. The fate of these plumes and the long-term impacts to downstream water quality has not been predicted, i.e. modelled.

The current extent of groundwater contamination downstream of the TSF is not well understood because these plumes have yet to be modelled and monitoring appears to be inadequate.

There has not been an assessment of historic and current seepages on the beneficial uses of groundwater over the long-term and (related) future liabilities.

3. ALTERNATE TAILINGS DISPOSAL OPTIONS

URS (2006) ranked the following two options according to *technical performance, seepage performance, residual environmental risk* and *cost* (final scores are shown in brackets):

1. Rehabilitation of Above Ground Storage (62)
2. Disposal of Tailings to Post Pit Mining (49)

The rationale for the scoring and results of the assessment seem appropriate, based on issues related to seepage.

The following options were also compared:

1. Optimise Existing TSF cells (62)
2. New TSF Area Outside Floodplain (57)

The scores for the above are close.

Given that the final scores for the two options (shown in brackets) are close, and the significant issues related to historic seepage via aquifers within shallow alluvial sediments, consideration of other TSF sites is warranted.

4. ANALYSIS OF SEEPAGE MANAGEMENT OPTIONS

The assessment of seepage management options for the TSF was undertaken by MRM/URS using a multi-criteria selection/assessment approach as well as predictive modelling.

4.1 DEVELOPMENT OF MULTI-CRITERIA SELECTION MATRICES

URS (2006) ranked the following four options according to *technical performance, seepage performance, residual environmental risk* and *cost* (final scores are shown in brackets):

1. Clay Liner to TSF (47)
2. Deep Low-Permeability Cut-off (51)
3. Dewatering Bores (70)
4. Geomembrane Liner (64)

A sensitivity analysis was undertaken by URS (2006) to see if the final ranking of options is altered by placing different weightings on the four criteria. The results of the analysis indicated that Option 3. still remains the preferred option. Despite this, a concern exists that a number of assumptions underpinning the scoring are not appropriate, and so an independent scoring of the options was undertaken. The results, including comments for scores that are different to those made by URS (2006), are contained in Appendix B. In summary, the 'dewatering bores' option received the lowest score.

A discussion of alternatives considered during the design phase is contained in Section 2.2.2 in URS (2006). Three options are presented and discussed:

1. Clay Lining of the TSF Footprint
2. Deep Low-Permeability Cut-off
3. Geomembrane Liner

A number of construction/performance issues and difficulties were identified for each option. It is considered that these difficulties can be readily overcome with the development of robust and appropriate designs. For example, Options 1. and 3. (above) could, with other design components (eg base drains, cut-off drains), be utilised to substantially restrict the hydraulic connection between the tailings and the underlying soils and hence substantially limit seepage to underlying aquifers.

It is considered that the basis for selecting seepage recovery bores as the key element of the seepage management strategy cannot be justified using the selection criteria applied.

4.2 PREDICTIVE MODELLING

Solute transport modelling is generally undertaken to predict changes to downstream water quality as a consequence of seepage from tailings storage facilities. In this case, impacts to downstream water quality were inferred on the basis of the changes to groundwater levels downstream of the TSF. Given the limited groundwater level data used during calibration and the karstic nature of the rocks, it is considered that the modelling results incorporate significant uncertainty which has not been appropriately quantified. This conclusion is supported by the fact that the model (forward) predictions of seepage recovery vary significantly from the Draft EIS to URS (2006), supporting the above comment.

The Draft EIS assumes seepage recovery bores were positioned on the southern side of the TSF spaced at 50 m centres to depths of approximately 11 m. Recovery bores would need to be operated for 30 years or longer after decommissioning to avoid surface expression of seepage waters. Solar or wind powered pumps would be used after closure. The total pumping rate would be 200 kL/day.

The PER assumes 32 seepage recovery bores are required pumping at 60 kL/day over 10 years, for up to 40 to 50 yrs after closure. Despite claims of their effectiveness, seepages are not fully recovered, as evidenced by contours of 'level change' extending to distances of at least 2 to 3 km south-west of Cell 1. Sensitivity analysis was carried out to assess a 'worst case' scenario where the base rock had a lower permeability. Results of this 'worst case' scenario are of serious concern, because they indicate that seepage rates are lower and the time taken to lower the head of water within the TSF is <u>increased</u>. During mine operations, it is estimated the seepage to water table ranges from 580 to 1,130 kL/day, equivalent to 100 to 200 mm/year. Total abstraction equals 1,980 kL/day during mine operations and is predicted to be 390 kL/day after 10 years.

In URS (2006), it was assumed that a total of 59 bores are required, pumping at a total rate of 1,846 kL/day during the period of mine operations, 745 kL/day after 5 to 10 yrs and 548 kL/day for 10 to 25 yrs post operation.

The basis upon which pumping is ceased (post-closure) is not clear.

5. DISCUSSION OF TSF SEEPAGE MANAGEMENT STRATEGY

5.1 DESIGN PHILOSOPHY

The proposed TSF will comprise three cells, the existing TSF (83 ha), Cell 1 (56 ha) and Cell 2 (62 ha). The total tailings volume is 23 Mm^3. Settled density is assumed to be 1.3 t/m^3. The tailings bleed water and stormwater runoff flow down the beached tailings to decant groynes, and may flow to the dirty water dam. It is not known whether there are seepage issues associated with the dirty water dam.

The PER states that the overall strategy to manage the risk of environmental impact from the TSF comprises a "multiple lines of defence" strategy, that has been developed for the three key stages of the life of the TSF. Key elements to manage seepage from the TSF (taken from Table 7.1 in PER) include:

- embankment to have clay core with cut-off key;
- ponded water in TSF to be kept away from perimeter embankment;
- geopolymer barrier to be installed around eastern embankment;
- network of recovery bores to be installed around entire TSF perimeter;

- TSF to be capped with low permeability layer, to prevent ongoing entry of water at closure; and
- maintain recover bores post closure, until seepage head in TSF reaches design level.

An "observational approach" will guide the operation of the seepage recovery bores (the key element of seepage minimisation), with additional bores assumed to be the contingency measure.

5.2 DESIGN CONSIDERATIONS & ASSUMPTIONS

Despite historic problems with tailings seepage, investigations of alternative sites for the TSF, that contain less permeable soils/rocks that would result in much less seepage from the TSF, were not undertaken. The new TSF will adjoin the existing TSF and will be constructed without seepage containment (i.e. a seepage limiting layer). The principal difference in design between the existing and new TSF is the establishment of a seepage recovery network to collect seepage during the period of mine operations and for 30 to 50 years after mine closure.

MRM considers initial capital costs as an "issue of critical importance", whereas operational costs, closure capital costs and post closure operational costs are (individually) seen to be an "issue of average importance" (URS, 2006). It could be implied that inadequate seepage containment measures were included in the TSF design to minimise initial capital costs with operational/post-closure costs not adequately considered. This is not considered to be *best practise* and does not meet the ANCOLD (1999) guidelines relating to integrated life-cycle management of tailings storage facilities[1]. Indeed, the design would not be approved in Victoria (DPI, 2004), where storage of contaminated tailings has a minimum level of containment mandated *"…the standard level of containment should be at least equivalent to 0.6 metre of clay, with permeability no greater than 10^{-8} m/sec."* Similarly, guidelines prepared by EPA QLD (2002) would also not be met because the design does not meet 'Design Principle (f)' which states that *"Seepage through or beneath external embankments should be minimised as far as practicable"*.

5.3 PERFORMANCE OF SEEPAGE CONTROL MEASURES

5.3.1 Operational Period

The absence of a seepage limiting layer provides operational benefits because it results in higher rates of tailings consolidation and settlement and higher tailings densities, thus permitting construction of a smaller TSF and resulting in lower initial capital and ongoing construction costs. But, it permits much greater seepage from the tailings to underlying aquifers and hence groundwater contamination.

MRM operation of the seepage recovery bores during the period of mine operations requires an "observational approach", an ongoing refinement that implies that new areas of groundwater contamination will be detected, requiring regular re-design of the bore network and regulatory review and management. Seepage will be an ongoing (major) issue for assessment by EPA and/or DPIFM during mine operations, and will rely heavily on appropriate data being made available by MRM for assessment.

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[1] ANCOLD (1999) Section 9.3 states that *"Decommissioning, closure and aftercare are more effective, efficient and economic if the storage has been planned, operated and managed with closure in mind."*

During mine operations, water will be pumped from the seepage recovery bores to the Proposed Water Management Dam. A water balance for the Dam has not been undertaken. It is stated that if there is insufficient capacity in the Dam (for storage of water pumped from seepage recovery bores) that seepage water will be spread as low rate irrigation over the TSF active cell during dry weather, at rates that do not result in runoff or ponding. This could result in a salt build up at the surface of the tailings as a result of evaporation, which will be leached into the tailings mass each wet season. It is concluded that the water quality of seepage passing through the base of the tailings dam will deteriorate over time.

5.3.2 Post-Closure Period

A conceptual cover design has been developed to minimise infiltration to the TSF. There is a concern that groundwater model used may not be well calibrated because average rainfall recharge rates across the model are assumed to be 10 to 20 mm/yr and yet the cover will permit 65 mm of infiltration each year. The conceptual cover design is therefore likely to be inappropriate because it does not appear to limit infiltration to the TSF to rates that are less than 'natural' rainfall-recharge.

The TSF design does not meet the requirements of relevant tailings management guidelines in terms of decommissioning. ANCOLD (1999) states that *"Decommissioning and aftercare maintenance should be anticipated and adequate provision made to ensure that it can continue for as long as is necessary to ensure that the decommissioning objectives and self sustainability are achieved."* The need for operation of a seepage recovery system beyond closure means that the TSF cannot achieve any degree of self sustainability. It is further stated that *"Ongoing requirements for the aftercare phase should be within the capability of the post-closure land user or other party responsible for the storage to implement. Therefore, aftercare requirements should be compatible with end-user capabilities and vice versa."* In this instance, it is considered that likely end users would be ill equipped to manage such a complex seepage management program. The design does not meet other guidelines[2].

The TSF design does not satisfy guidelines in the context of its post-closure performance and requirement for ongoing management.

[2] According to EPA (1995) in MCMPR/MCA (2003), there are a number of objectives that need to be considered when planning the final land form of a tailings storage facility. These include *"containing/encapsulating tailings to prevent leaching into ground and surface waters"* and *"designing the closure to minimise post-closure maintenance"*. The design of the TSF, including cover design, indicate that the tailings are neither contained or encapsulated to prevent leaching into groundwater and post-closure seepage recovery requirements is indicative of substantial post-closure maintenance.

ANZMEC/MCA (2000) states that *"Being able to successfully close a mine is critical to project approval. It is necessary to ensure that closure is technically, economically and socially feasible without incurring long-term liabilities."* Long-term seepage recovery (post-closure) means that the MRM site is left with a significant environmental liability at the time of closure. In the event that MRM withdrew from the site at this time, the Northern Territory government would need to utilise available funds held in trust on behalf of MRM or other funds to manage a liability over a period of 30 to 50 years.

6. OTHER ISSUES

There are a number of inconsistencies in statements contained in URS (2006) that are not supported by the results of the studies (particularly modelling) and should be of concern to NRETA/EPA. For example:

pES-1: *"The assessment concluded that the network of recovery bores was the preferred option. The clays available on site have a long-term permeability similar to the tailings, and so offer no advantage. ….The use of a geomembrane liner would inhibit consolidation of the tailings and provide a long-term environmental risk"*. The statements misrepresent the benefits that both options could provide in limiting seepage from the TSF; in effect clay is not sufficiently impermeable but a geomembrane liner is too impermeable?

p.ES-2: *"During operations and for the post-closure period during which the recovery bores are operating, there will be no TSF seepage reporting to the underlying groundwater…"* Barriers or liners separating the tailings from the underlying aquifers are not planned to be installed, so the statement that there will be no TSF seepage reporting to the underlying groundwater is factually incorrect.

p. ES-2: *"Thus any groundwater seepage from the TSF that does not express at Surprise or Barney Creeks eventually reports to the underground mine, which is a regional sink in the groundwater flow system."* The comment that seepage will ultimately enter the underground mine cannot be support by the information available, given that there is inadequate groundwater monitoring and the fact that solute transport modelling has not been undertaken.

p. 5-6: *"Some contamination of groundwater could occur at depth if the recovery bores are ineffective. However an assessment of the results of the current groundwater monitoring program that has included the effects of seepage from the existing TSF shows that the quality of the groundwater will still meet the ANZECC guidelines for livestock water quality (Section 4.2.3). Therefore the risk of deteriorating groundwater quality is not significant."* Groundwater at TSF mostly does not meet the livestock guideline value (for sulfate), and based on historic trends continuing, seems unlikely to meet the guideline value in the future.

7. CONCLUSIONS

1. The impacts of historic and current seepage from the existing TSF are not fully understood and the legacy issues related to this seepage (future impacts to receiving waters) have not been modelled and assessed;

2. There has not been an assessment of alternative, more appropriate TSF sites that would not contain permeable alluvial soils, that in turn would limit seepage from the TSF and hence reduce environmental risk;

3. It is unlikely that the TSF design would be approved in other states, based on available guidelines.

4. During the period of mine operations, contaminated groundwater from the seepage recovery bores may be pumped back to the TSF in the dry season. This could cause a long-term deterioration of seepage water quality, thus extending the time for seepage recovery

5. Post-closure, the TSF would not be self-sustainable and therefore does not meet ANCOLD (1999) guidelines.

6. In the unlikely event that MRM were placed into receivership before or at the end of mine operations, the NT Government would be left with a very substantial environmental liability that would require ongoing, costly management for a period of decades.

8. RECOMMENDATIONS

It is recommended that other designs for the TSF are developed and assessed with the prime objectives of limiting seepages to the underlying groundwater system (in the first place) and achieving compliance with relevant guidelines and standards for the operational and post-closure management of TSFs.

9. REFERENCES

Australian National Committee on Large Dams (1999). *Guidelines on Tailings Dam Design, Construction and Operation*. October 1999.

Australian and New Zealand Minerals and Energy Council/Minerals Council of Australia (2000). *Strategic Framework for Mine Closure*. Joint publication.

EPA (Queensland) (1995). *Tailings Management*. Industry Guidelines. January 1995.

Department of Primary Industries (2004). *Environmental Guidelines – Management of Tailings Storage Facilities.* State of Victoria, Department of Primary Industries, Minerals & Petroleum Division. November 2004.

Ministerial Council on Mineral and Petroleum Resources / Minerals Council of Australia (2003). *Strategic Framework for Tailings Management*. Joint publication.

URS (2006). *McArthur River Mine Open Cut Project, Public Environmental Report, Response to Further Information Request.* Report prepared for McArthur River Mining. 14 August 2006.

APPENDIX A –
COPY OF LETTER FROM THE MINISTER FOR NATURAL RESOURCES, ENVIRONMENT AND HERITAGE TO THE GENERAL MANAGER – MRM (31 JULY 2006)

Fax sent by : 31/07/06 10:50 Pg: 2/3

MINISTER FOR NATURAL RESOURCES,
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Mr Brian Hearne
General Manager
McArthur River Mining Pty Ltd
PO Box 36821
WINNELLIE NT 0821

Dear Mr Hearne

The Public Environmental Report for the amended proposal to expand the McArthur River Mine is on public exhibition until 31 July 2006. I consider that the information set out in Attachment A is necessary to facilitate examination of the report.

In accordance with clause 11(2)(a) of the *Administrative Procedures of the Environmental Assessment Act*. I direct the project proponent to provide the necessary information set out in Attachment A.

My decision under clause 11 will be made within fourteen (14) days after I am satisfied that the necessary information has been received.

In the first instance, any questions of clarification in relation to this matter should be directed to Ms Lyn Allen, Executive Director, Environment and Heritage on telephone (08) 8924 4135.

Yours sincerely

MARION SCRYMGOUR
31 JUL 2006

Northern Territory Government

ıx sent by :

31/07/06 10:50 Pg: 3/3

ATTACHMENT A

Tailings Storage Facility

Background

1. The modelling of seepage from the **Tailings Storage Facility (TSF)** is semi-conceptual, with two-dimensional modelling (in the draft Environmental Impact Statement (EIS)) used to select "a network of recovery bores at the downstream toe of the perimeter embankment" as the preferred (seepage) mitigation measure, over the use of a "1m thick compacted clay layer below the tailings". Only two seepage mitigation measures were modelled in the draft EIS. A further two options were modelled in the Public Environmental Report.

   There does not seem to have been a thorough identification and assessment of seepage limiting options; it is considered that other 'passive' seepage limiting options could / should have been considered and modelled, eg geosynthetic liner to seal base of tailings with use of underblanket drain to collect tailings water before it enters the groundwater system, return of tailings to the pits (to reduce the need for long-term operation of an 'active' seepage recovery system).

2. The criteria for successful seepage mitigation is "to avoid surface expression of the seepage" in Surprise Creek. It is implicit that some degree of groundwater contamination is possible elsewhere (e.g. elevated groundwater levels are predicted to the south of the TSF). The impacts to groundwater quality (and hence beneficial uses) and surface water quality in other creeks / rivers was not modelled or discussed. It seems highly unusual that modelling focuses on groundwater 'mounding', and yet no attempt has been made to predict the fate and transport of seepage and impacts on downstream surface water or groundwater quality (during operations and post-closure).

Further Information request

- Provide thorough identification, modelling and assessment of further seepage limiting options, including 'passive' options (see above).

- Discuss the feasibility, costs / benefits and potential hydrological / environmental impacts in the short and long term of further tailings disposal options, including in-pit disposal of tailings, and shifting the TSF to adjacent higher ground (above the floodplain).

- Provide any recent report(s) that describe existing TSF monitoring and the fate / impacts of historical seepage, particularly in relation to seepage that may have bypassed Surprise Creek or may be occurring in other areas. Describe historical TSF seepage in terms of hydrogeological destinations.

- Discuss in detail future TSF seepage and model impacts to groundwater quality and surface water quality in creeks / rivers other than Surprise Creek. Predict the fate and transport of future seepage and impacts on downstream surface water or groundwater quality (during operations and post-closure).

APPENDIX B - EWL SCIENCES SCORING OF SEEPAGE LIMITING OPTIONS

MRM Open Cut Project - Seepage Control

Option Selection Criteria

Project Objective (KRA)	KRA Group Weighting	Key Per I	KPI Individual Weighting	Ranking Scores: Clay Liner to TSF Raw Score	Clay Liner to TSF Weighted Score	Deep Low Permeability Cutoff Raw Score	Deep Low Permeability Cutoff Weighted Score	Dewatering Bores Raw Score	Dewatering Bores Weighted Score	Geosynthetic Liner Raw Score	Geosynthetic Liner Weighted Score	Comments
Technical Performance	25%	Improved tailings placement - (density achieved)	2	3	6	3	6	3	6	2	4	
		Provide stable landforms	4	3	12	3	12	3	12	3	12	
		Emissions to the environment (erosion, dust)	4	3	12	3	12	3	12	3	12	
		Disturbed area/footprint	2	2	4	3	6	3	6	2	4	
		Storage efficiency - (incl upstream lifts)	1	3	3	3	3	3	3	2	2	
		Maximum KPI weighted score	65	Σ	37	Σ	39	Σ	39	Σ	34	
		KRA Group Weighted Sub-Total		14%		15%		15%		13%		
Seepage Performance	25%	No surface expression of seepage	4	3	12	3	12	4	16	5	20	1. Impact on receiving waters for dewatering bores from 4 to 2 because contaminated waters are constantly pumped from depth to the surface; high risk of pump or pipe failure leading to ongoing spills, leaks and untracked losses to creeks or contamination of other groundwater bodies
		Impact on receiving waters	4	3	12	3	12	2	8	5	20	2. Beneficial uses of surface and groundwater for dewatering bores from 4 to 2 for same reason as 1.
		Beneficial uses of surface and groundwater	4	3	12	3	12	2	8	5	20	3.Clay liner on TSF for all criteria from 1 to 3 because no information presented to suggest that clay not available or likely to be ineffective (particularly given that clay available for TSF walls)
												3.Deep low permeability cutoff for all criteria from 1 to 3 because no information presented to suggest that clay not available or likely to be ineffective (particularly given that clay available for TSF walls)
		Maximum KPI weighted score	60	Σ	36	Σ	36	Σ	32	Σ	60	
		KRA Group Weighted Sub-Total		15%		15%		13%		25%		
Seepage Performance	25%	Established precedent	2	3	6	3	6	3	6	3	6	1. Potential for seepage legacy from dewatering bores from 5 to 1 because mounding extends beyond bores & risks associated with pump equipment failure, human error, pumping of seepage water back to TSF thus increasing recycling salts and resulting poorer quality seepage from TSF over time
		Construction risks	1	3	3	3	3	4	4	3	3	2. Potential for seepage legacy from geosynthetic liner from 2 to 4 because liner limits impacts to groundwater system in the first instance so legacy issues likely to be lower in the long-term
		Ability to augment/implement contingencies	3	3	9	3	9	3	9	3	9	3. Ability to augment/implement contingencies for all options likely to be the same for all options, so all options given scores of 3
		Reliance on post closure attendance	4	4	16	4	16	2	8	5	20	
		Potential for seepage "legacy"	3	3	9	3	9	1	3	4	12	
		Maximum KPI weighted score	65	Σ	43	Σ	43	Σ	30	Σ	50	
		KRA Group Weighted Sub-Total		17%		17%		12%		19%		
Seepage Performai	25%	Initial capital costs	4	2	8	3	12	4	16	1	4	1. Individual weightings for 'closure capital costs' and 'post closure operational costs' increased because less certainty of finance at times where no cash flow
		Operational costs	2	3	6	3	6	2	4	3	6	2. Closure capital costs for geo liner from 1 to 3 because costs for option overstated; cover should limit infiltration irrespective of liner presence
		Closure capital costs	3	3	9	3	9	4	12	3	9	3. Closure capital costs from 5 to 4 for dewatering bores because non-power issue requires substantial refit
		Post closure operational costs	4	3	12	2	8	1	4	4	16	4. Post-closure operational costs from 2 to 1 will be unacceptable
												4. Post-closure operational costs from 2 to 3 for cutoff and clay liner
		Maximum KPI weighted score	50	Σ	35	Σ	35	Σ	36	Σ	35	
		KRA Group Weighted Sub-Total		18%		18%		18%		18%		
				63%		**64%**		**58%**		**75%**		