REVIEW OF THE McARTHUR RIVER MINE OPEN CUT PROJECT PUBLIC ENVIRONMENTAL REPORT

By

Professor Wayne D. Erskine
Centre for Sustainable Use of Coasts and Catchments
School of Environmental and Life Sciences
University of Newcastle – Ourimbah Campus
PO Box 127
Ourimbah NSW 2258

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The shortcomings in the information contained in the Draft EIS and Supplement for the McArthur River Mine Open Cut Project were outlined in my first report (Erskine, 2006) and have been meaningfully addressed in the Public Environmental Report (URS, 2006). In particular,

- Hydrological information is now presented for Barney and Surprise creeks.
- The errors in ground elevation for the photogrammetrically determined cross sections have been discussed along with how these are translated into uncertainty in the calculated water surface levels and hydraulic parameters in HEC-RAS.
- The adopted roughness coefficients have been changed so that they are spatially variable to cover the range of site conditions. The recalibrated flood model for the January 2003 flood, as a result, has a much better fit to the known flood profile.
- The very high shear stresses and specific stream powers in the current channel of the McArthur River coincide with extensive bedrock outcrops.
- Additional geomorphological work has shown that the McArthur River is generally stable, except for some minor pockets of bank erosion. Surprise Creek and Barney Creek downstream of its junction with Surprise Creek are unstable. However, the modified design for the river diversion should improve river stability.
- Meaningful river reach analysis has now been completed for the McArthur River and for Barney and Surprise creeks and has been used in the redesign of the two diversion channels. The types of channel units or aquatic habitats have also be documented and included in the redesign of the river diversions.

Improvements in the design of the river diversions include

- Inclusion of artificial rock riffles in the diversion channels.
- Incorporation of large wood loadings, spacing, orientation and accumulations in the diversion channel design that mimick the current channel. However, large wood must be appropriately sourced and such sources have not been discussed.
- Details of the revegetation proposal have now been outlined.
- Meaningful discussion of sediment erodibility for the material used to form the banks of the diversion channel has been provided and the measures taken to decrease erodibility have been outlined.
- The modified designs for the diversion channels should be stable but need to be monitored at least annually until riparian vegetation is re-established.

The original predicted impacts of the diversion channels on up- and downstream channel morphology were based on the information contained in the Draft EIS and Supplement. The provision of better quality information in the Public Environmental Report has shown that the original predictions were overstated because:

- There are extensive bedrock bars and gravels exposed in the bed of the McArthur River and Barney Creek.
- The redesign of the diversion channels will result in a more stable channel than originally planned.
- Downstream deposition will not be as severe as originally predicted and a sand slug should not form.

- The banks of the diversion channel will be protected by rock-lining until dense riparian vegetation is re-established which will take more than 10 years.

The development of a government policy on river diversions and biodiversity offsets for river diversions would assist future assessment of similar proposals.

INTRODUCTION

This report was commissioned by Ms Juanita Croft and Mr Rod Johnson of Environmental Assessment, Northern Territory Environment Protection Agency, Department of Natural Resources, Environment and the Arts to critically review the new information included in the McArthur River Mine Open Cut Project Public Environmental Report (URS, 2006) for the proposed realignments of the McArthur River and Barney Creek for diversion around the proposed open cut pit.

The alignment of the two proposed diversion channels is shown in Figure 2.1 and a summary of the project modifications is outlined in Table 2.1 of URS (2006). The McArthur River diversion is discussed in Section 4 and the Barney Creek diversion in Section 5 of URS (2006).

The basis of this assessment is all of the following:

- URS' Draft Environmental Impact Statement for the original proposal (URS, 2005a).
- URS' Environmental Impact Statement Supplement for the original proposal (URS, 2005b).
- URS' Public Environmental Report for the modified proposal (URS, 2006).
- Field inspections of the McArthur River catchment in 2002.
- Aerial and on-ground inspections of the McArthur River, Barney Creek and Surprise Creek in the vicinity of the mine site on 18 May 2006 with representatives of URS and Northern Territory Environment Protection Agency.
- Air photograph interpretation of 1:50000 vertical air photographs flown in 1995.
- My earlier report on the original proposal (Erskine, 2006).
- Over 10 years lecturing and research on river restoration and river engineering.
- Previous and current research on channel diversions around open cut mines (for example, Hardie *et al.*, 1994).
- Continuing research on tropical river geomorphology and hydrology, including rivers draining to the Gulf of Carpentaria (for example, Erskine *et al.*, 2005; 2006a; 2006b; Saynor *et al.*, 2004; 2006a; 2006b).
- Continuing research on river rehabilitation (for example, Erskine, 2001; Erskine and Webb, 2003).
- Continuing research on the role of riparian vegetation and large wood in influencing channel morphology (for example, Erskine, 2003; Webb and Erskine, 2003a; 2003b).
- Use of HEC-RAS for the prediction of fish passage (Erskine, 2005a).
- River classification and reach analysis (for example, Erskine, 2005b; Erskine *et al.*, 2001; 2006a).
- Experience as a member of many expert scientific panels relating to rivers (Snowy River, Murrumbidgee River, rivers impacted by Snowy Mountains Hydroelectric Scheme, Coxs River, rivers impacted by Gosford-Wyong Water Supply Scheme, Daly River).

GUIDELINES FOR THE PREPARATION OF THE PUBLIC ENVIRONMENTAL REPORT

The Environment Protection Agency specified in its guidelines for the Public Environmental Report that the issues raised in Section 4.2 of the Environmental Assessment Report (Environment Protection Agency, 2006) and in Erskine (2006) should be addressed. The issues raised by Environment Protection Agency (2006) and not covered by Erskine (2006), included:

- Destruction of 6 km of riparian and riverine corridor.
- Resultant habitat fragmentation and its potential impacts on many species.
- Uncertainties on upstream and downstream aquatic environments.
- Effects on erosion and sedimentation and flow-on effects to other river reaches.
- Contaminant release through ground disturbance and metal mobilisation.
- Creation of a barrier to fish passage for smaller fish species and *Pristis microdon*.
- Establishment of a functioning ecological community on the realigned channel similar to the pre-disturbed McArthur River.
- Impacts on people living downstream.
- Implications for other Northern Territory and Australian rivers.

Erskine (2006) outlined the shortcomings in the information contained in the Draft EIS for the McArthur River Mine Open Cut Project Draft EIS (URS, 2005a) as:

- No hydrological information for Barney and Surprise creeks was provided.
- No errors were cited for the ground elevations for the photogrammetrically determined cross sections nor how these were translated into uncertainty in the calculated water surface levels in HEC-RAS hydrodynamic model.
- The adopted roughness coefficients were high but the HEC-RAS model calibration resulted in a poor fit to a known flood profile. The original roughness coefficients may be incorrect.
- The adopted grain size for McArthur River sediment was very fine and seemed inappropriate.
- There was a marked drawdown in the water surface profile immediately upstream of the diversion channel during the 1:2 and 1:5 year ARI events which produced very high shear stresses and specific stream powers that will cause erosion. This drawdown requires further investigation.
- Additional geomorphological work was required to determine whether the McArthur River and Barney and Surprise creeks are currently stable. No work had been undertaken on Barney and Surprise creeks.
- Meaningful river reach analysis needed to completed for the McArthur River and started for Barney and Surprise creeks to assist in the design of the two diversion channels. In particular, the types of channel units or aquatic habitats present must be documented.

Erskine’s (2006) recommended improvements in the design of the diversion channels included:

- Supplying appropriate information for the Barney and Surprise creeks diversion channel.

- Following the methods outlined in the Rehabilitation Manual (Rutherfurd *et al.*, 2000a; 2000b) for the design of the diversion channels.
- Outlining the method used to derive the channel geometry for the McArthur River diversion channel.
- Incorporating the same aquatic habitats as exist in the current channel in the diversion channel design.
- Incorporating large wood loadings, spacing, orientation and accumulations in the diversion channel design that mimick the current channel. Large wood must be appropriately sourced.
- Providing meaningful information on the revegetation proposal, including species, seed source, planting densities, vertical zonation of species, etc.
- Meaningful discussion of sediment erodibility for the material used to form the banks of the diversion channel and what measures will be taken to decrease erodibility.
- Details of the proposed channel monitoring program.
- Offsets for the destruction of 8 km of river channel by the two channel diversions.

The predicted impacts of the diversion channels on up- and downstream channel morphology included:

- No information was provided in the EIS to make any meaningful predictions of the potential impacts of the Barney and Surprise creeks diversion channel.
- Upstream progressing degradation will occur on the McArthur River due to the drawdown immediately upstream of the diversion channel and the consequent very high shear stresses. No information was presented in the EIS to enable an assessment of the likelihood that armouring would reduce the magnitude of bed degradation.
- Downstream deposition will occur on the McArthur River, converting the channel into a sand slug.
- The banks of the McArthur River diversion channel will erode until dense riparian vegetation is re-established which will take more than 10 years.

The following discussion addresses the additional information and analyses contained in the Public Environmental Report and how these impact on the original assessments.

McARTHUR RIVER DIVERSION CHANNEL

Figure 4.4 of URS (2006) shows the proposed alignment of the McArthur River diversion channel and flood protection bund. Figure 4.5 shows the long section of the diversion channel and Figure 4.6 shows typical cross sections.

Hydraulics

Erskine (2006) noted that the use of photogrammetrically-derived cross sections introduced an error in the computed water surface levels for all discharges because the ground levels are usually accurate to only ± 0.1 m or worse. No error term for the heights for such cross sections was mentioned in Appendix K of the Draft EIS (URS, 2005a) or how it translated into uncertainty in the calculated water surface levels. It has now been established by URS (2006) that the photogrammetrically-determined levels are accurate to ± 0.2 m but that they have been supplemented by ground surveys of the channel near the mine, which are accurate to ± 0.05 m. New sensitivity analyses by URS (2006) found that survey errors of ± 0.2 m produce less than a 1 % change in water surface levels for discharges less than the 5 year ARI flood. Therefore, the HEC-RAS results are not sensitive to the known errors in the survey data.

URS (2006) found that the effect of the survey errors on hydraulic parameters was greater than for water surface levels. Nevertheless, the modelled hydraulic outputs are still useful for impact assessment and serve to indicate the likely potential changes due to the river diversion.

Erskine (2006) suggested that the original roughness coefficients used for model calibration of the January 2003 flood were high and noted that no supporting material was presented to justify the adopted values. Detailed work has now been completed in URS (2006) on estimation of the roughness coefficients, which has resulted in the use of spatially variable but appropriate values.

Model calibration of the January 2003 flood heights was relatively poor for the two gauging stations (approximately 0.5 m higher at the MIM gauge and 0.5 m lower at the DIPE gauge) for the original flood model, indicating that further work was still needed to refine the hydraulic model (Erskine, 2006). The use of variable instead of constant roughness coefficients at the cross sections used in HEC-RAS resulted in a much better fit to measured flood levels for the January 2003 flood in URS (2006). The recalibrated model underestimated flood peak heights by only 0.1 to 0.14 m (URS, 2006).

Erskine (2006) suggested that the equation and r^2 for the relationship shown in Figure K.4 of URS (2005a) should be added to the figure. This has now been completed (Chart 4.6 in URS (2006)). The HEC-RAS results for flow velocities plot within the scatter of the data measured at the gauging station, which is an acceptable result.

Erskine (2006) expressed concern at the magnitude of the specific stream power/shear stress on the McArthur River under natural and diverted conditions. Erskine (1999) found that when specific stream power exceeds 35 W/m^2, sand-bed channels usually erode. On the McArthur River, specific stream power often exceeds 80 W/m^2 and hence the channel should be either a very active sand-bed stream with many pockets of rapid bank erosion or contain long sections of channel protected by extensive bedrock bars exposed in the channel boundary. URS (2006) point out that the high specific stream powers calculated under natural conditions occurred where bedrock was exposed in the channel or where some large-scale flow restriction was present. I agree with this assessment following the aerial and on-site inspections of the McArthur River. Figure 1 shows some of the many bedrock bars that are present in the upstream anabranching reach. Figure 2 shows the extensive, steep bedrock rapids at the downstream end of Djurinmini Waterhole. Many trees have had their trunks snapped by the high shear stresses experienced on these rapids and most trees have a marked downstream lean.

While URS (2006) concluded that the channel of the McArthur River was stable upstream of the entrance to the diversion channel in the anabranching reach, there are pockets of bank erosion (Figure 4C). These pockets seem to occur where there are gaps in the riparian vegetation due to flood disturbance and/or grazing damage or where there are channel bifurcations around islands or where there are locally steeper sections over bedrock bars. The channel is not as active as originally expected (Erskine, 2006) because of the often dense riparian vegetation and the multiple bedrock bars. Nevertheless, the channel is also not as stable as suggested in URS (2006).

Figure 1. Bedrock exposed in the bed of the main channel in the upstream anabranching reach. (W.D Erskine photographs).

Figure 2. Steep bedrock rapids downstream of Djirinmini Waterhole showing downstream leaning trees and snapped tree trunks. (W.D Erskine photographs).

The design of the diversion channel has been modified so that it now incorporates, among other things (URS, 2006: Table 4.17 and text):

- Reduced slope for the upstream segment of the diversion channel where it is located in alluvium.
- Steeper slope for the section of the diversion channel excavated through bedrock.
- Inclusion of six artificial rock riffles (Newbury and Gaboury, 1993) in the diversion channel.
- Greater density of large woody debris.
- Additional floodplain width by modifying the flood protection bund.
- Stepped energy dissipation structure at the confluence with Bull Creek.
- Use of rock armour to protect alluvial banks from erosion.
- Use of geofabric to protect dispersible soils from erosion.
- A maximum stream power of 65 W/m^2 to enable vegetation to grow on the banks of the diversion channel.

The HEC-RAS results for the proposed modified diversion channel design show that flow velocities are usually kept below 2.2 m/s and that specific stream power is usually kept below 150 W/m^2 for flood events up to the 1:500 year flood. The rock-lining of the alluvial banks and the size of the gravel used in the artificial rock riffles should have been selected to withstand the calculated specific stream powers. While URS (2006) does not indicate that the shear stress procedure of Newbury and Gaboury (1993) was followed, the specific stream power method of Annandale (1995) was certainly used. Erskine (2006) recommended that the erodibility of the material to be exposed/filled on the banks of the diversion channels should be determined. The method of Annandale (1995) was used to quantitatively assess material erodibility in relation to specific stream power by URS (2006). It was found that the silty sand in the diversion channel had the lowest resistance to erosion but could withstand specific stream powers up to 95 W/m^2. This only applies to non-dispersible and/or non-slakeable material, which does not lose coherence on wetting. Dispersible sediment is so highly erodible that it totally and rapidly disaggregates when wet (Emerson, 1967) and will erode at very low specific stream powers. Bedrock in the diversion channel can withstand specific stream power of at least 17000 W/m^2. Unfortunately, sands up to 2 mm in diameter are mobilised by flows with specific stream powers of < 1 W/m^2 (Annandale, 1995: Tables 10 and 11). Such sands are present in the channel in the upstream anabranching reach (Figure 3) and will be transported into the diversion channel. While it is likely that the diversion channel will be stable, it is essential that its condition is assessed every dry season, at least until riparian vegetation has been re-established, which is likely to take at least 10 years.

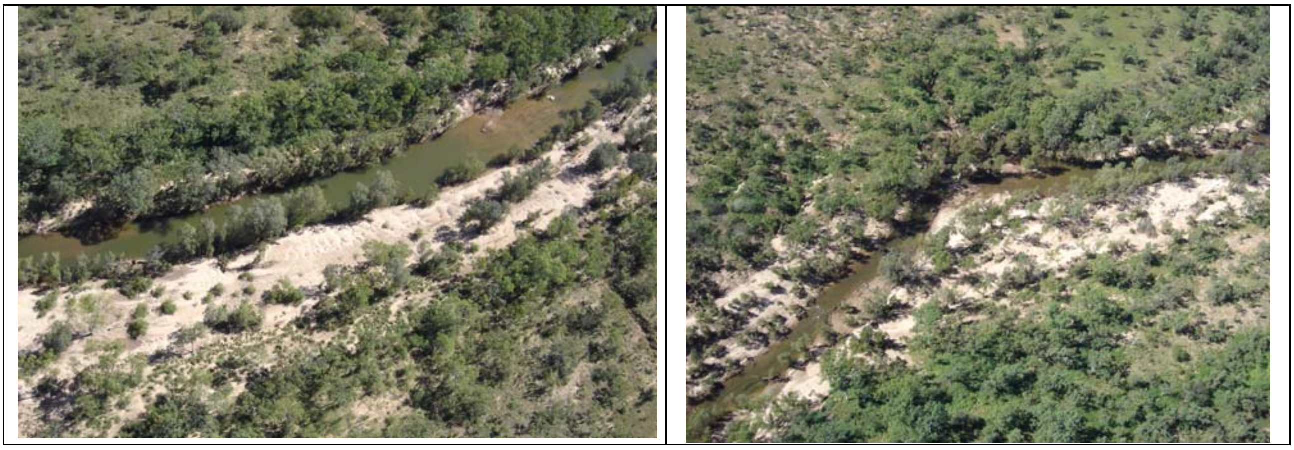

Figure 3. Sand deposits in the channel of the upstream anabranching reach of the McArthur River. (W.D. Erskine photographs).

Geomorphology

Erskine (2006) concluded that Section 12.6 of the Draft EIS was poor and needed revision so that it corrected the erroneous information presented on the fluvial geomorphology of the McArthur River. River reaches have now been defined for the McArthur River in Section 4.3 of URS (2006). Erskine (2006) also noted that channel reaches are the appropriate spatial scale to define specific reach or river types. This has now been done with the description of three reaches, namely the upstream anabranching reach, the low sinuosity mine reach and the Bukalara bedrock-confined reach downstream of the mine (Figure 4). These reaches were discussed on-site with URS personnel and revise the errors in the Draft EIS. The photographs in Figure 5 confirm the data in the Public Environmental Report (URS, 2006).

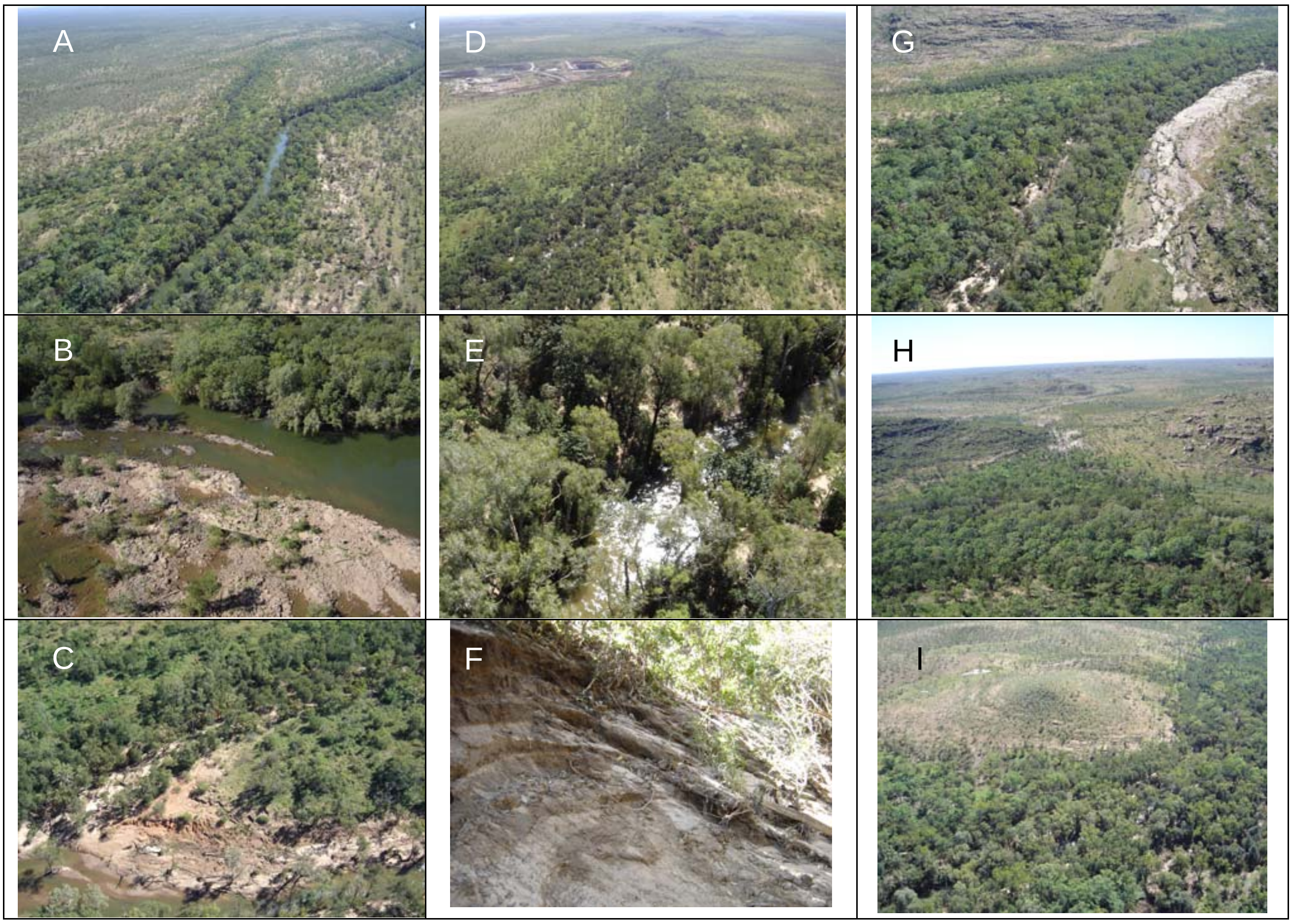

Figure 4. (A) Upstream anabranching reach showing the deep main channel and shallower anabranches on the wide floodplain. (B) One of the numerous bedrock bars in the river bed of the main channel of the anabranching reach, which were not mentioned in the Draft EIS (URS, 2005a). (C) One of the occasional examples of bank erosion present in the anabranching reach, which were not mentioned by URS (2006). (D) The low sinuosity mine reach next to the test pit. (E) Run which is the dominant channel unit in the low sinuosity mine reach. (F) Steeply channel-dipping, intercalated mud and sand units which have been obliquely accreted on the channel banks of the low sinuosity mine reach. (G) Well-vegetated Bukalara bedrock-confined reach downstream of the mine. (H) Another example of a well-vegetated section of the Bukalara bedrock-confined reach (I) Bedrock mound beside the channel in the Bukalara bedrock-confined reach. Such mounds also occur on the floodplain in the upstream anabranching reach (All photographs by W.D. Erskine).

Pools and riffles have been included in the design of the diversion channel because of the inclusion of artificial rock riffles. Pools and riffles involve morphological complexity in the bed profile that create diverse hydraulic conditions that will assist fish passage through the diversion channel. While the low sinuosity mine reach is characterised by an essentially continuous run, the proposed channel units for the diversion channel are still appropriate.

Erskine (2006) noted that the citation of data for one cross section at the DIPE gauging station in the upstream anabranching reach must be supplemented by additional data to justify calling the existing channel near the mine as stable (see URS, 2005a, Appendix K, p. K-24). The representativeness of a single piece of site specific data is always a concern. By itself, it is not helpful. As noted in URS (2006), aerial inspection of the upstream anabranching reach revealed numerous bedrock bars in the bed of the main channel and occasional sections of bank erosion (Figure 4C). Furthermore, high parts of the floodplain were also eroded by rilling and gullying and appeared to be associated with overgrazing of dispersible/slakeable soils (Figure 5).

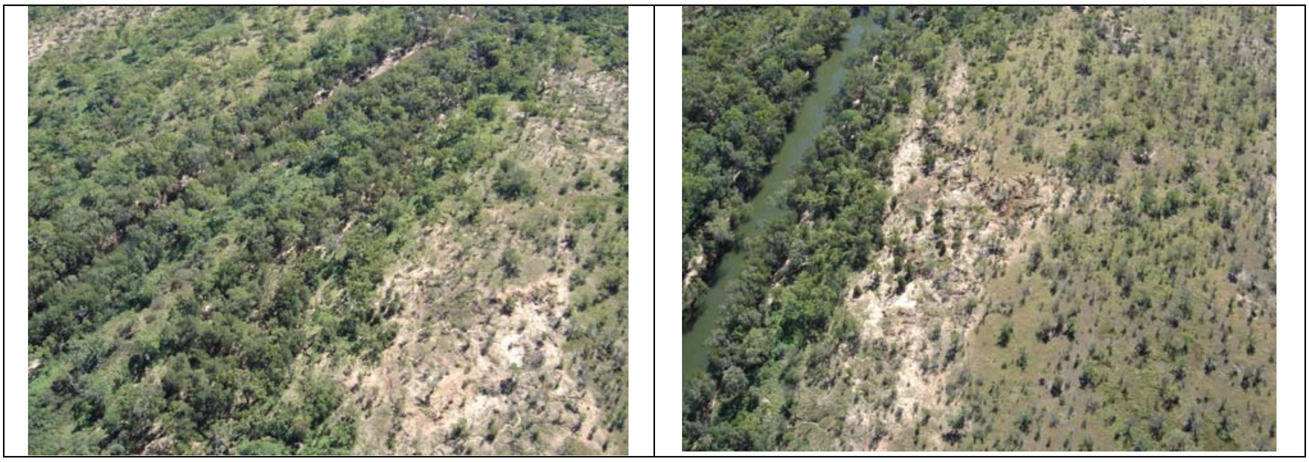

Figure 5. Natural levees in the upstream anabranching reach eroded by rilling and gullying of dispersible/slakeable soils (W.D. Erskine photographs).

Erskine (2006) predicted that upstream progressing degradation will occur upstream of the diversion channel because of the very high specific stream power. The Draft EIS did not discuss whether bedrock was exposed in the channel boundary where the HEC-RAS model indicated that there were very high specific stream powers. Armouring is a natural self-stabilising tendency of rivers which selectively erodes the finer sediment in the bed material and concentrates the coarser sediment on the bed surface. Gravel armour layers produced by bed degradation are monolayers that coat and hence protect the finer underlying sediment from erosion. The Draft EIS did not investigate armour layers. My initial concerns have been reduced because bedrock is exposed in the channel bed at sites of high specific stream power and a significant gravel fraction is present in many sections of channel in the upstream anabranching reach (see above).

Similarly the predicted deposition downstream of the diversion channel on the McArthur River is not as significant an issue as first assessed because upstream sediment supply is unlikely to be as great as initially predicted. Upstream bed degradation and bank erosion of the diversion channel are unlikely to be as great as predicted because of the modifications to the diversion channel design in the Public Environmental Report and the presence of bedrock in the channel boundary. The predicted sand slug should not form, provided the diversion channel performs as predicted in URS (2006).

The banks of the diversion channel have also been redesigned so that they will be protected by a gravel armour layer and the specific stream power of the redesigned diversion channel are now lower than originally designed. The six artificial rock riffles also reduce the slope of the energy grade line.

The time needed for plant establishment will be relatively long in this strongly seasonal climate. Dispersible sediment may also cause major erosion problems. Therefore, it is essential that annual inspections of the diversion channel are conducted at least until riparian vegetation is well established.

Aquatic Habitats
Hawkins *et al.* (1993) defined channel units (or aquatic habitats) as quasi-discrete areas of relatively homogeneous depth and flow that are bounded by sharp physical gradients. Each channel unit exhibits different physical characteristics and can also be associated with habitat-specific fish species assemblages (Petersen and Rabeni, 2001a; 2001b). Erskine (2006) concluded that it is essential to know what aquatic habitats or channel units are present on the channels that will be diverted so that they can be incorporated into the design for the diversion channels. Section 4.4 in the Public Environmental Report (URS, 2006) discusses the results of a field survey of aquatic habitats of the low sinuosity mine reach of the McArthur River which is used as an analogue of the diversion channel. The channel unit that dominates this reach is the run set within well-vegetated, steep-sided banks of a sand-bed, low sinuosity main channel flanked by high natural levees. Living trees and large woody debris are important structural habitats.

Erskine (2006) noted that there were no data on large wood loadings, spacing, orientation and accumulations in the Draft EIS (URS, 2005a). Large wood has now been incorporated into the design of the two diversion channels, based on the characteristics of large wood in the current channel (see Section 4.4 on Aquatic Habitats in URS (2006)). However, appropriate sources of large wood have still not been identified to ensure that existing trees are not removed from river channels and floodplains. Large wood often induces scour that forms a range of pool types that are important aquatic habitats (Webb and Erskine, 2005). Such scour is unlikely in the bedrock sections of the diversion channel but may occur in the alluvial sections.

Revegetation
Erskine (2006) strongly supported the revegetation proposal, but noted that there were no details of the program contained in the Draft EIS (URS, 2005a). A revegetation management plan has been included in the Public Environmental Report (URS, 2006) as part of the rehabilitation works and covers species selection, vertical zonation of species, seed sources, maintenance of genetic integrity, site preparation, planting techniques, etc. Long stem plantings should be trialled because they have proved very effective in surviving without irrigation in southern Australia (Dr Anita Chalmers, 2006, personal communication).

BARNEY CREEK DIVERSION CHANNEL

Figure 4.4 of URS (2006) shows the proposed alignment of the McArthur River diversion channel and flood protection bund. Figure 5.3 shows the long section of the diversion channel and Figure 5.4 shows typical cross sections.

Erskine (2006) noted that little design information on the Barney Creek diversion channel was included in the Draft EIS (URS, 2005a) and that no hydrological data were presented. Furthermore, he also concluded that the fluvial geomorphology and aquatic habitats of Barney and Surprise creeks were not addressed in the Draft EIS (URS, 2005a) and so the diversion channel design could not be assessed as to how well it mimicked the natural channel.

The design of the Barney Creek diversion channel has been modified since the Draft EIS and its Supplement (URS, 2005a; 2005b). The fluvial geomorphology and aquatic habitats of Barney and Surprise creeks are discussed in Sections 5.3 and 5.4, respectively of the Public Environmental Report (URS, 2006). Significantly, field inspections have established that the lower section of Barney Creek is often backwater-affected by the McArthur River, as evidenced by its channel morphology and the perched nature of the channel bed of Barney Creek above the main stream. Furthermore, there are many bedrock outcrops in the channel and gravel lag deposits. Nevertheless, there are extensive areas of bank erosion, pool scour and flood chute development on Surprise Creek (Figure 6). These indicate that Surprise Creek is not as stable as Barney Creek and responds to floods.

Figure 6. Bank erosion, pool scour and flood chute development on Surprise Creek. (W.D. Erskine photographs).

Design peak flow estimates have now been calculated and are shown in Table 5.2 of the Public Environmental Report (URS, 2006). Furthermore, an extreme storm on Surprise Creek has also been considered in Section 5.5.2.

Following the procedure discussed above for the McArthur River, URS (2006) have evaluated spatially variable roughness coefficients for the HEC-RAS hydraulic model. The adopted values (Tables 5.3 and 5.4 and text in URS (2006)) are appropriate.

For the hydraulic modelling using HEC-RAS, URS (2006) have evaluated the effects of backwater from the McArthur River and no backwater as well as the extreme storm over the Surprise Creek catchment. No backwater from the McArthur River would represent an extreme case scenario. Under existing conditions, very high specific stream powers and shear stresses (>100 N/m^2 and >300 W/m^2, respectively) are experienced on Surprise Creek and Barney Creek downstream of the Surprise Creek junction. These channels are eroding and exhibit flood chutes which have been excavated into the floodplain (Figures 6 and 7). URS (2006) called the chutes on lower Barney Creek, cutoffs, but they are not abandoned channels in former meander loops, as occurs with cutoffs (Erskine and Melville, 1982; Erskine *et al.*, 1992). Instead, they are actively functioning channels that convey flood waters and are eroding the floodplain. They are not currently stable, as stated in the Public Environmental Report (URS, 2006: p. 5-24).

The original design for the Barney Creek diversion channel would have caused erosion because 600 mm diameter rock would have been mobilised (URS, 2005a: p. 5-27). Therefore, the diversion channel design has been modified as outlined in pp. 5-28 to 5-30 in the Public Environmental Report (URS, 2006). Seven artificial rock riffles (Newbury and Gaboury, 1993) have been included along with coarse rock-lining of the bed and/or banks at many locations, among other things. The modifications reduce maximum flow velocities to below those currently experienced in the natural channel. From the HEC-RAS results for the modified diversion channel and the results of an erodibility assessment using Annandale (1995), the modified diversion channel will withstand the shear stresses and specific stream powers, provided all the protection works outlined in the Public Environmental Report (URS, 2006), are implemented.

Figure 7. Flood chute and low flow channel on lower Barney Creek downstream of the Surprise Creek junction. (W.D. Erskine photograph).

The Public Environmental Report (URS, 2006) has largely addressed all of the issues that I raised in my earlier report (Erskine, 2006). To ensure that the Barney Creek diversion channel functions as designed, it is essential that annual inspections of the diversion channel are undertaken until riparian vegetation has been re-established. This will take at least 10 years. The frequency of inspections can be reduced thereafter.

A revegetation management plan has been included in the Public Environmental Report (URS, 2006) for the Barney Creek diversion channel as part of the rehabilitation works and should be implemented.

OTHER ISSUES

The McArthur River Mine Open Cut Project has been assessed in the absence of a government policy for river diversions in the NT. Clearer direction and guidelines to government agencies, developers and interested individuals for any such future proposals would occur if the NT Government was to develop a policy on river diversions.

A diversion channel monitoring program involving geomorphology, hydrology, hydraulics and ecology should be implemented if approval is given to the present proposal.

Biodiversity offsets covering the realigned diversion channels should also be covered by Government policy. Rehabilitation of at least an equivalent length of channel to that destroyed by the two diversions (8 km) should be included in any proposal for a river diversion. There needs to be a strong economic incentive for mining companies to exhaustively consider all alternatives to river diversions and, if a diversion is the only option, its length should be reduced to the shortest possible.

CONCLUSIONS

The shortcomings in the information contained in the Draft EIS and Supplement for the McArthur River Mine Open Cut Project have been meaningfully addressed in the Public Environmental Report (URS, 2006). In particular,

- Hydrological information is now presented for Barney and Surprise creeks.
- The errors in ground elevation for the photogrammetrically determined cross sections have been discussed along with how these are translated into uncertainty in the calculated water surface levels in HEC-RAS.
- The adopted roughness coefficients have been changed so that they are spatially variable to cover the range of site conditions. The calibrated flood model, as a result, has a much better fit to a known flood profile.
- The very high shear stresses and specific stream powers in the current channel of the McArthur River coincide with extensive bedrock outcrops.
- Additional geomorphological work has shown that the McArthur River is generally stable, except for some minor pockets of bank erosion. Surprise Creek and Barney Creek downstream of its junction with Surprise Creek are unstable. However, the modified design for the river diversion should improve river stability.
- Meaningful river reach analysis has now been completed for the McArthur River and for Barney and Surprise creeks and has been used in the redesign of the two diversion channels. The types of channel units or aquatic habitats have also be documented and included in the redesign of the river diversions.

Improvements in the design of the river diversions include

- Inclusion of artificial rock riffles in the diversion channels.
- Incorporating large wood loadings, spacing, orientation and accumulations in the diversion channel design that mimick the current channel. However, large wood must be appropriately sourced.

- Details of the revegetation proposal have now been outlined.
- Meaningful discussion of sediment erodibility for the material used to form the banks of the diversion channel has been provided and the measures taken to decrease erodibility have been outlined.

The original predicted impacts of the diversion channels on up- and downstream channel morphology were based on the information contained in the Draft EIS and Supplement. The provision of better quality information in the Public Environmental Report has shown that the original predictions were overstated because:

- There are extensive bedrock bars and gravels exposed in the bed of the McArthur River and Barney Creek.
- The redesign of the diversion channels will result in a more stable channel than originally predicted.
- Downstream deposition will not be as severe as originally predicted and a sand slug should not form.
- The banks of the diversion channel will be protected by rock-lining until dense riparian vegetation is re-established which will take more than 10 years.

The development of a government policy on river diversions and biodiversity offsets for river diversions would assist future assessment of similar proposals.

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