

10.0 Groundwater

10.1 Summary

As part of the EIS studies (URS, 2005a; 2005b), a groundwater flow model of the project area was used to assess the impacts of the proposed open-cut mine on the groundwater resources of the area. The model has shown that the dewatering (using perimeter production bores) that would be required to maintain dry and efficient mining conditions in the open pit has the potential to drawdown groundwater in the vicinity of Djirrinmini Waterhole by about 0.35 m at the end of the mine life (25 years).

The potential lowering of the depth of the Djirrinmini Waterhole could reduce aquatic habitat diversity, increase temperatures, and reduce protection from predators. A decrease in waterhole depth would also affect overall size and volume of the waterhole, and therefore reduce habitat availability for aquatic fauna. However, recent aquatic surveys of this waterhole indicate that it is probably too small to be significant as a refuge pool for larger fish species such as the freshwater sawfish and barramundi, and is likely to support only widespread and fast breeding species. The most significant waterhole in the river for these larger fish species is Eight Mile Waterhole, which will not be affected by drawdown.

The lowering of groundwater levels around the waterhole would have the potential to lead to stress in riparian fringing vegetation. However, given the generally low permeability of the bedrock between the waterhole and the proposed open cut, it is expected that the drawdown will occur slowly over the 25 years of the project's life, and that riparian vegetation will therefore be able to respond to the drawdown by the propagation of deeper root systems.

Groundwater drawdown also has the potential to reduce the inflow of groundwater into the river in instances where the groundwater table is above the river bed. It has been estimated that this could extend the no-flow period in the river at the end of the dry season by up to 14 days per year on average towards the end of the mine life. The river ecology is already adjusted to extensive periods of no flow, which occur at the end of the dry season during most years. As the existing no-flow period in the river already varies from several weeks to several months depending on seasonal conditions, the extension of this no-flow period by 14 days is not expected to have any significant effect on the river's aquatic ecology. It will not affect fish migration, including that of the sawfish, because at the end of the dry season, all migratory aquatic fauna will be already established in more permanent refuge pools.

An extensive monitoring program of Djirrinmini Waterhole will be undertaken and will include water quality, water levels and aquatic biology. Groundwater levels will also be monitored. As significant impacts are not expected until towards the end of the mine life, there will be adequate time to develop any necessary mitigation measures. Such measures could include adding water to Djirrinmini Waterhole from another water source in order to maintain levels during the dry season.

10.2 Potential Drawdown Effects on Djirrinmini Waterhole

The most important surface water feature in the area potentially affected by the Open Cut Project operations is the Djirrinmini waterhole, which is located approximately 1 km upstream of the proposed open cut.

Groundwater modelling indicates that after 25 years of groundwater abstraction associated with mine dewatering, about 0.35 m of drawdown in the weathered bedrock and alluvium under and near the waterhole could occur.

Although the river pools and alluvium are recharged by stream flow on a seasonal basis, this magnitude of drawdown has the potential to affect both the level and longevity of the pools towards the end of the dry season, as pools are dependent on groundwater inflow during the dry season.

Groundwater studies show that Djirrinmini Waterhole is largely supported by groundwater discharge from the alluvium and palaeochannel sediments. If drawdown occurs in the alluvium and palaeochannel sediments underlying and surrounding the waterhole, there is potential to:

- Lower the water level in the waterhole at the end of the dry season, compared to natural conditions
- Stress riparian vegetation (in and around the waterhole area) that relies on water in the waterhole at the end of the dry season
- Reduce base flow in the McArthur River earlier in the dry season, than would naturally occur.

While Djirrinmini Waterhole is the only permanent or semi-permanent waterhole that could be affected by groundwater drawdown, recent aquatic surveys of this waterhole (Appendix L) indicate that it is probably too small to be significant as a refuge pool for larger fish species such as the freshwater sawfish and barramundi, and is likely to support only widespread and fast breeding species. The most significant waterhole in the river for these larger fish species is Eight Mile Waterhole, which will not be affected by drawdown.

The potential lowering of the depth of the Djirrinmini Waterhole towards the end of the project period (25 years) could reduce aquatic habitat diversity, increase temperatures, and reduce protection from predators. A decrease in waterhole depth would also affect overall size and volume of the waterhole, and therefore reduce habitat availability for aquatic fauna.

Riparian vegetation is generally a groundwater dependant ecosystem, which relies on shallow groundwater under and in the banks of the river during the dry season. If groundwater levels are lowered under and around the waterhole and river channel by open cut dewatering, groundwater flow into the river channel and to this vegetation would be reduced. This would have the potential to lead to vegetation stress, if the drawdown occurs quickly. Vegetation can better respond to lowering groundwater levels if the lowering occurs slowly.

Given the generally low permeability of the bedrock between the waterhole and the proposed open cut, it is expected that the drawdown will occur slowly over the 25 years of the project life, and that riparian vegetation will therefore be able to respond to the drawdown by the propagation of deeper root systems.

Historical water levels in the Djirrinmini Waterhole have never been monitored and are unknown. It is therefore possible that historically, and under natural (pre-mining) conditions, the waterhole has previously dried or has had very low water levels during past dry seasons. Some anecdotal reports indicate that this has occurred. However, the drying out of the waterhole in the past cannot be established definitively, and therefore it is proposed that mitigation strategies will be put in place to protect the environment in and around the waterhole from any such potential impacts. These mitigation measures are discussed in 10.4.

It is important to note that any impact on the waterhole will be temporary, will not occur suddenly, and is not expected to start to occur for some years. This provides ample opportunity to establish a monitoring program and to develop any necessary mitigation measures.

The natural groundwater and surface water regimes will be re-established after the completion of mining, and dewatering activities at the mine will cease.

10.3 Potential Impacts from Extension of No-Flow Period in McArthur River

Due to the hydraulic connection between the river and the underlying aquifers, there is potential for a reduction in river flows to occur in the immediate vicinity of the mine due to groundwater drawdown. Based on the refined conceptual hydrogeological model, the estimated reduction in river flow to the strata underlying the river in the first year of dewatering is 60 kL/day. After year 25 this is expected to increase to 350 kL/day.

The loss of 350 kL/day is only 1.5% of the average dry weather flow of 23,000 kL/day and, given the significant natural variation in river flows, is not expected to have any noticeable effect on the aquatic environment.

Groundwater drawdown also has the potential to reduce the inflow of groundwater into the river in instances where the groundwater table is above the river bed. Based on stream gauging measurements, up to approximately 375 kL/day of groundwater is discharged into the river in the reach upstream of the start of the diversion channel. This flow is the maximum likely reduction in stream flow that could be attributed to drawdown. Based on river gauging measurements, these maximum flow periods (up to 375 kL/day) only occur for 14 days per year on average.

The river ecology is already adjusted to extensive periods of no flow, which occur at the end of the dry season during most years. The predicted extension of the no-flow period due to mine dewatering is predicted from groundwater modelling to only occur over the last few years of the mine life.

As the existing no-flow period in the river already varies for several weeks to several months depending on seasonal conditions, the extension of this no-flow period by an additional maximum of 14 days is not expected to have any significant effect on the river's aquatic ecology. It will not affect fish migration, including the sawfish, because all migratory aquatic fauna will be already established in more permanent refuge pools at the time of flow reductions.

10.4 Management and Mitigation Strategies - Djirrinmini Waterhole

10.4.1 Proposed Management Strategy

It is proposed to use a pro-active management strategy which includes refining the current knowledge of the hydrogeology of the Djirrinmini Waterhole. This will allow more accurate predictions and early warnings of impacts associated with mine dewatering. The management strategy would include:

- Establishing additional groundwater monitoring bores around the waterhole prior to the commencement of dewatering, and incorporating these into the existing groundwater monitoring network
- Completing permeability testing in these bores, and updating hydrogeological cross sections in the area of the waterhole
- Establishing a regular sampling and level measurement schedule for these bores on a monthly basis, as part of an established groundwater monitoring program around the mining area
- Updating and refining the regional groundwater model, as additional data become available.

It is proposed that an annual ‘evaluation’ report, which discusses the results of all monitoring programs near the waterhole and assesses any potential impacts from mine dewatering, would be prepared. This report would also include the results of the monitoring of aquatic/terrestrial biota and riparian vegetation. Where appropriate, the report would provide triggers for the implementation of mitigation strategies; these are discussed below.

If as a result of dewatering, the waterhole becomes consistently dry during the dry season, both the aquatic/terrestrial biota and riparian vegetation dependent on the groundwater will be impacted. The proposed monitoring program, which will have been in place for a number of years previously, will give an early warning of potential impacts on biodiversity, and there will be sufficient time for appropriate mitigation measures to prevent this to be put in place.

10.4.2 Mitigation Strategies

During future periods of high stress and low water levels associated with mine dewatering, it is possible that the Djirrinmini Waterhole may have to be supplemented from another water source in order to maintain levels during the dry season. This can only be confirmed by long-term groundwater level monitoring in bores near the waterhole, and ongoing refinement of the groundwater model (to predict future impacts) as new groundwater data become available.

There are a number of potential options for sourcing supplementary water, including:

- Pit dewatering discharge – this source is considered to be generally not suitable, as discharge will be significantly more saline than the Djirrinmini Waterhole, and could include metals above background levels
- Local bedrock groundwater from a production bore near the waterhole – this is also more saline than the waterhole, and generally not of suitable quality

- Groundwater from alluvial and palaeochannel aquifers downstream of the waterhole, being pumped as part of the pit water control system – this groundwater is of suitable quality and is readily available. This water could be added directly to the waterhole, or re-injected into the alluvium and palaeochannel sediments near and around the waterhole.

Alluvial/palaeochannel groundwater, pumped as part of the river diversion/pit interception scheme, is the best source of supplementary water for the Djirrinmini Waterhole. This low salinity groundwater is of suitable quality, and is readily available from the already proposed pumping program associated with river diversion/pit interception.

Should the monitoring program indicate that supplementary water supply is required, a pipeline could be installed from the bores to an acceptable location in the vicinity of the waterhole (possibly upstream). Water would be added to the waterhole to maintain an acceptable water level until the next wet season.

As an alternative to discharging the alluvial/palaeochannel groundwater directly into the waterhole or in an upstream location, it could be reinjected into the alluvium and palaeochannel sediments near and around the waterhole, using a series of small re-injection bores, perhaps upstream and downstream from the waterhole. This would:

- Decrease the migration of the dewatering cone from the open cut in the vicinity of the Djirrinmini Waterhole, thereby reducing the potential for drawdown impacts
- Maintain the water table elevation in the alluvium and palaeochannel sediments during the dry season, thereby maintaining waterhole water levels during the dry season.

10.4.3 Sacred Site Significance

Djirrinmini Waterhole is a Registered sacred site (6165-5). Any reduction in the size, volume, or longevity of this waterhole towards the end of the dry season may affect its cultural/sacred values. One of the features of Site 6165-5 is that particular trees within 50 m of the waterhole and the rock bar also have sacred features. The protection of these cultural/sacred values will be recognised in the implementation of the proposed mitigation strategies described above. In accordance with the requirements of the Aboriginal Areas Protection Authority, MRM will apply for an Authority Certificate before implementing any mitigation measures such as adding water to the waterhole or the drilling of any additional groundwater monitoring bores in or near the site.

10.5 Proposed Monitoring Program

10.5.1 Refinement of Groundwater Flow Model for Drawdown Prediction

It is proposed that the groundwater flow model would continue to be the main predictive tool to forecast drawdown under and near the Djirrinmini Waterhole. As such, the model would be updated on a regular basis, as new hydrogeological information is obtained. It is expected that new information would generally comprise:

- Results from the open cut dewatering program and the regional propagation of the drawdown cone

- Results from the drilling, monitoring and testing of additional groundwater monitoring/production bores.

As each update of the model occurs, additional predictive runs would be completed to refine estimates of future drawdown under and near the waterhole. Such predictions would be used to determine triggers to implement mitigation strategies.

10.5.2 Baseline and Annual Riparian Vegetation Surveys

In order to assess any potential impacts of groundwater level lowering on riparian vegetation along the McArthur River in the area of the Djirrinmini Waterhole, it is proposed that a program of riparian vegetation monitoring would be initiated. This would comprise an initial baseline survey to establish the plant communities present in the area and to determine their groundwater dependence and estimated ecological water requirements.

Annual surveys of this vegetation would be undertaken during the life of the mine. Any assessment which indicates impacts would trigger the operation of the selected mitigation scheme.

10.5.3 Water Flow, Level and Quality Monitoring - Djirrinmini Waterhole

It is proposed that a monitoring program for Djirrinmini Waterhole, including groundwater levels and chemistry, and surface water chemistry and levels during the dry season, would be established prior to the commissioning of the mine dewatering system.

To date, four clusters of shallow and deep groundwater monitoring bores have been established near the Djirrinmini Waterhole, and these have been incorporated into the mining area groundwater monitoring network and are monitored on a regular basis. The locations of these boreholes is shown in Figure 10.1. Any new groundwater monitoring bores would also be incorporated into this schedule.

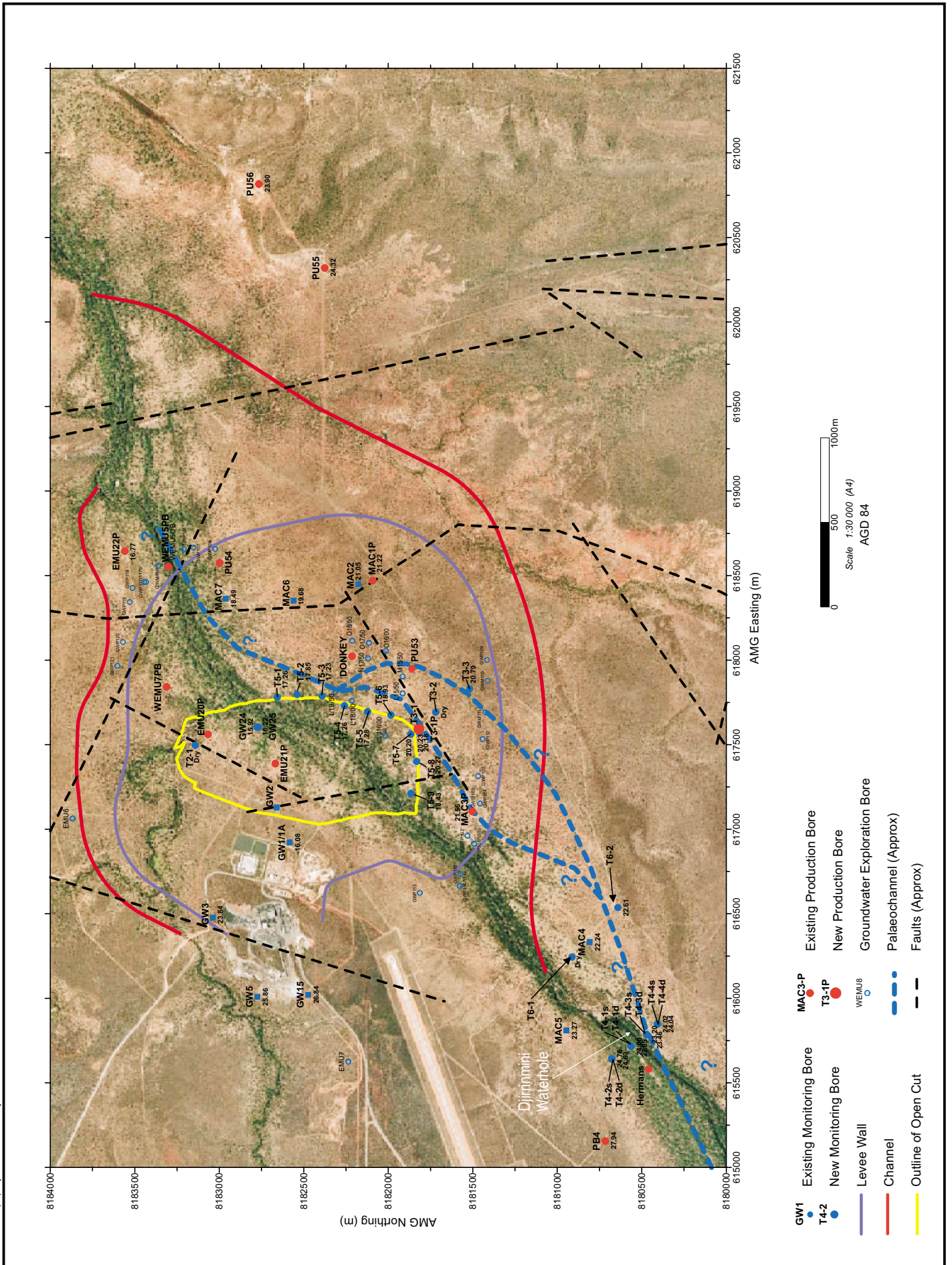
The present program of ongoing stream flow and surface water level/quality measurements in the McArthur River at the end of the dry season would continue, in order to:

- Refine estimates of groundwater discharge to the river
- Assess groundwater/surface water interaction
- Clarify the groundwater dependence of the Djirrinmini Waterhole
- Predict potential environmental impacts associated with open cut dewatering.

Results from this monitoring program would be evaluated, and would be used as a basis to determine triggers for the implementation of mitigation strategies, should the monitoring show that mitigation strategies are required.

10.5.4 Aquatic Biota

In order to assess any potential impacts of groundwater level lowering on aquatic biota in Djirrinmini Waterhole, it is proposed that a monitoring program would be instigated. An initial baseline survey of



MCARTHUR RIVER MINE
OPEN CUT PROJECT
PUBLIC ENVIRONMENTAL REPORT

BOREHOLE LOCATIONS

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fishes in Djirrinmini Waterhole has already been completed (Appendix L). The waterhole would be included in the regular aquatic monitoring studies, which are outlined in Section 11.2.4.

Results from the aquatic biota monitoring program would be evaluated, and would be used as a basis to determine triggers for the implementation of mitigation strategies, should the monitoring show that mitigation strategies are required.