8.1 Existing conditions

URS were commissioned to undertake groundwater investigations at the Andranangoo and Lethbridge deposits to elucidate the hydrogeology and assist in designing a predictive groundwater flow model to assess the potential environmental impacts of process water borefield operation. This program has also helped to determine the hydrogeological characteristics of the alluvial aquifers underlying both deposits.

Full documentation of the groundwater investigation undertaken as part of the EIS studies is given in Appendix B. This chapter summarises the results of that investigation.

8.1.1 Geology

The stratigraphy of the Tiwi Islands is summarised in Table 8.1 and described below.

Table 8.1 Stratigraphy of the Tiwi Islands (Modified after Haig et al, 2003)

Formation	Age	Depth (m)	Lithology
Superficial Formations	Quaternary	< 10	Alluviual Silt/Sand/Gravel sediments.
Van Diemen Sandstone	Tertiary	0 - >60	Fine to medium grained quartzose sandstone.
UNCONFORMITY			
Moonkinu Member	Cretaceous	0 – 100	Very fine sandstone with interbeds of grey carbonaceous mudstone and siltstone.
Wangarlu Mudstone Member	Cretaceous	0 – 500	Mudstone/Siltstone.
Mullaman Beds	Cretaceous	600 - 750	Sandstone/Shale.
UNCONFORMITY			
Basement	Proterozoic	700+	Igneous/metamorphics.

The oldest rocks underlying the Tiwi Islands are Proterozoic basement comprising igneous and metamorphic rocks. Overlying the basement are thick units of Cretaceous Mullaman Beds that comprise sandstone and shale about 100 m thick. Overlying the Mullaman Beds is the Wangarlu Member (the oldest outcropping rock type on the Tiwi Islands), which comprises predominantly mudstone and is approximately 500 m thick.

Overlying the Wangarlu Member is the Moonkinu Member that comprises a very fine to fine-grained sandstone with interbeds of grey carbonaceous mudstone and siltstone. There is a sandstone horizon within the Moonkinu Member that hosts a regional confined aquifer.

Overlying the Cretaceous Moonkinu Member is the Tertiary Van Diemen Sandstone, a friable, white to yellow, medium to coarse-grained quartzose sandstone with subordinate intercalations of grey carbonaceous mudstone and siltstone of fluvial to paralic origin. The Van Diemen Sandstone dips and thickens to the north, with the unit exposed over a 60 m vertical section at Cape Van Diemen at the extreme northwestern tip of Melville Island (Matilda Minerals, 2004).

Unconsolidated Quaternary fluvial, paralic, deltaic and littoral deposits, overlie both the Moonkina Member and Van Diemen Sandstone. The most economically significant of these are the Pleistocene littoral quartzose sands associated with the palaeo-shoreline. Holocene (Recent) littoral deposits have accumulated along the present coastline, variously abutting or transgressing the Cretaceous, Tertiary and Pleistocene deposits (Matilda Minerals, 2004).

8.1.2 Groundwater geology and aquifer occurrence

Regional

The regional groundwater resources of the Tiwi Islands have been described previously by Haig *et al*, 2003, and this is summarised below.

Regionally, unconfined aquifers occur in: (i) saturated portions of the Van Diemen Sandstone; and (ii) superficial sand sediments. Typically, there is a 10 to 30 m unsaturated zone in the Van Diemen Sandstone. Regionally, the Van Diemen Sandstone is present on most of Melville and Bathurst Islands, where the maximum known thickness is approximately 70 m.

Regionally, the basal portion of the Mookinu Member (Sandy Horizon) is the main confined aquifer system under the Melville and Bathurst Islands. It comprises grey sandstone with thin interbeds of grey siltstone and claystone and dips towards the northwest. The aquifer is approximately 30 to 60 m thick and occurs at about sea level (0 m AHD) in the central part of Melville Island and extends below sea level (-110 m AHD) at the north coast.

Regional groundwater quality is fresh for both unconfined (Van Diemen Sandstone) and confined aquifers (Mookinu Member, Sandstone Horizon). Bores constructed within unconfined aquifers located close to the coast can have brackish to saline groundwater, where a saltwater interface with the ocean is present. With the exception of pH, the groundwater in the unconfined and confined aquifers on Melville and Bathurst Islands is within the ANZECC water quality and monitoring guidelines for all community production bores (Haig *et al*, 2003).

Andranangoo

Groundwater occurs within unconfined aquifers within the saturated Van Diemen Sandstone and superficial sediments on the coastal plain. Superficial sediments are limited in extent and thickness (generally less than 5 m) and usually coincide with the strand-line deposits. In the eastern project area, the superficial sediments are considerably thicker and may represent an old erosion channel in the Van Diemen Sandstone.

Lethbridge

Similar to Andranangoo, aquifers occur within superficial sediments on the coastal plain and the underlying Van Diemen Sandstone. From the drilling results, superficial sediments at Lethbridge are generally 5 m thick or less.

8.1.3 Groundwater supply

Three test production bores were constructed at Andranangoo on the coastal plain and one potable water camp supply bore located on the scarp (Figure 2.4). At Lethbridge, one test production bore was drilled and one camp water supply bore was constructed (Figure 2.5).

Three water supply bores were installed for haul road dust suppression. An existing bore "Three-ways bore" was airlift developed and aquifer tested to determine the suitability of the bore as a supply bore for water for road dust suppression (Figure 8.1).

Production bores were drilled to supply a small domestic water supply at Port Melville (Figure 1.5).

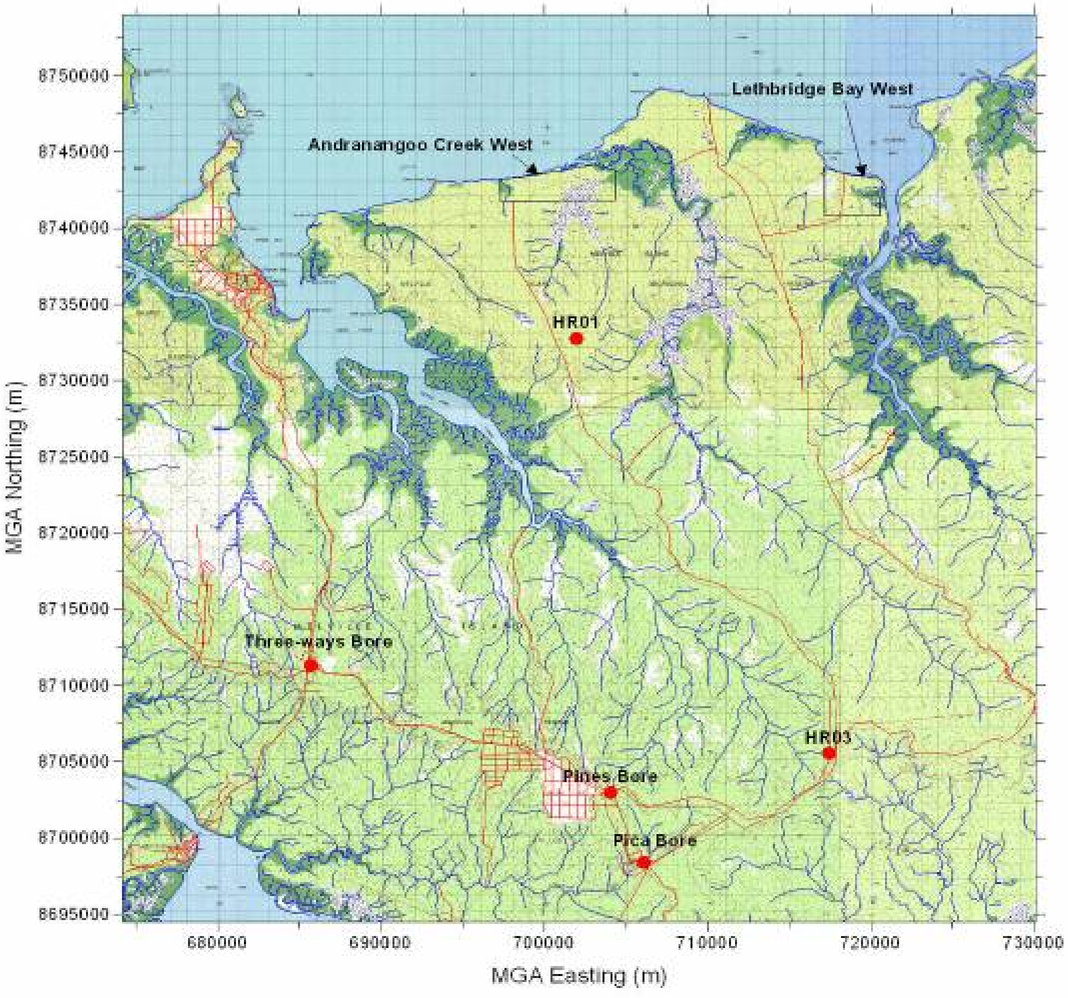
8.1.4 Groundwater supply and monitoring bores

Andranangoo

Since early 2005, Matilda Minerals has established a regional network of groundwater monitoring bores to determine any potential impacts of the current mining operations on the groundwater resources of the area (Figure 2.4). The monitoring bores are located across the mine area and on the scarp where the camp water supply bore is located.

Lethbridge

Seven groundwater monitoring bores (Sites 1 to 8) were drilled and constructed to determine the hydrogeology at Lethbridge and to allow for the determination of potential impacts of the mining operations on the groundwater resources of the area (Figure 2.5). The monitoring bores are located across the mine area and on the scarp where the water supply bore is located.



Road
Drainage
Water Supply Bore

Scale 1 : 400,000
Projection: GDA 94, Zone 52
0 10 20km

Job No.	42213693		Matilda Minerals MINERAL SANDS PROJECT- DRAFT EIS	**Figure 8.1**
Prep. By	CMAC	9 Sept. '05		
Chk'd By	RIJV	9 Sept. '05	**BORE LOCATIONS HAUL ROAD DUST SUPPRESSION**	URS
Revision No.		0		

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Figure 8.1.srf

8.1.5 Groundwater levels and flow

Andranangoo

Groundwater levels across the mining area, for the end of the dry season in 2005, are presented in Figure 8.2. There is a northerly flow of groundwater from high elevations on the scarp to lower elevations on the coastal plain (about 1.5 m RL).

Based on recent groundwater monitoring, wet season groundwater levels are 2 to 3 m higher than dry season groundwater levels, suggesting this is about the magnitude of seasonal variation.

Lethbridge

Groundwater levels across the mining area, for the end of the dry season in 2005, are presented in Figure 8.3. There is a northerly flow of groundwater from high elevations on the scarp to lower elevations on the coastal plain (elevation approximately 0.8 m RL).

Based on recent groundwater monitoring at Andranangoo Creek West, wet season groundwater levels are likely to be 2 to 3 m higher than dry season groundwater levels, suggesting this is about the magnitude of seasonal variation.

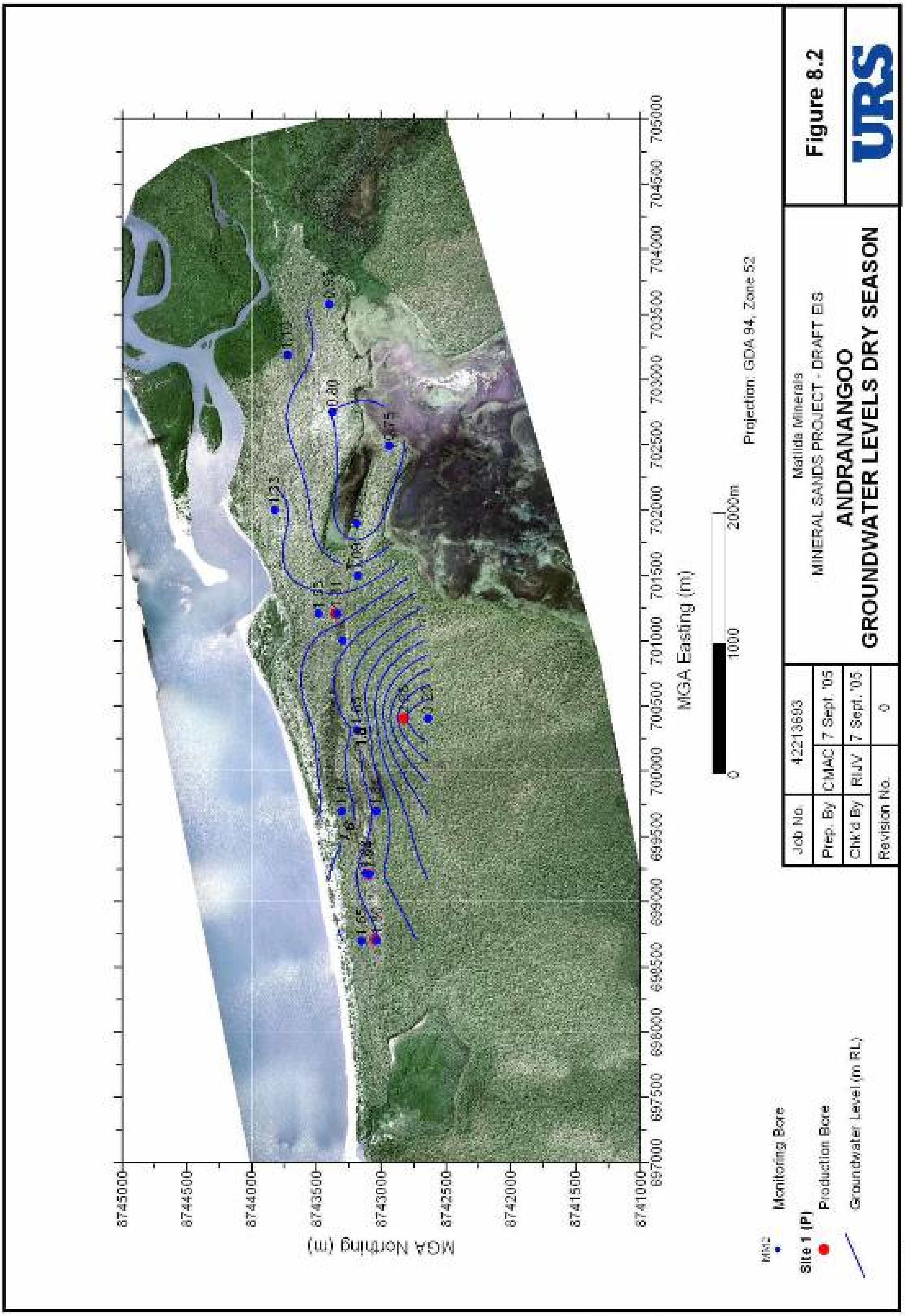
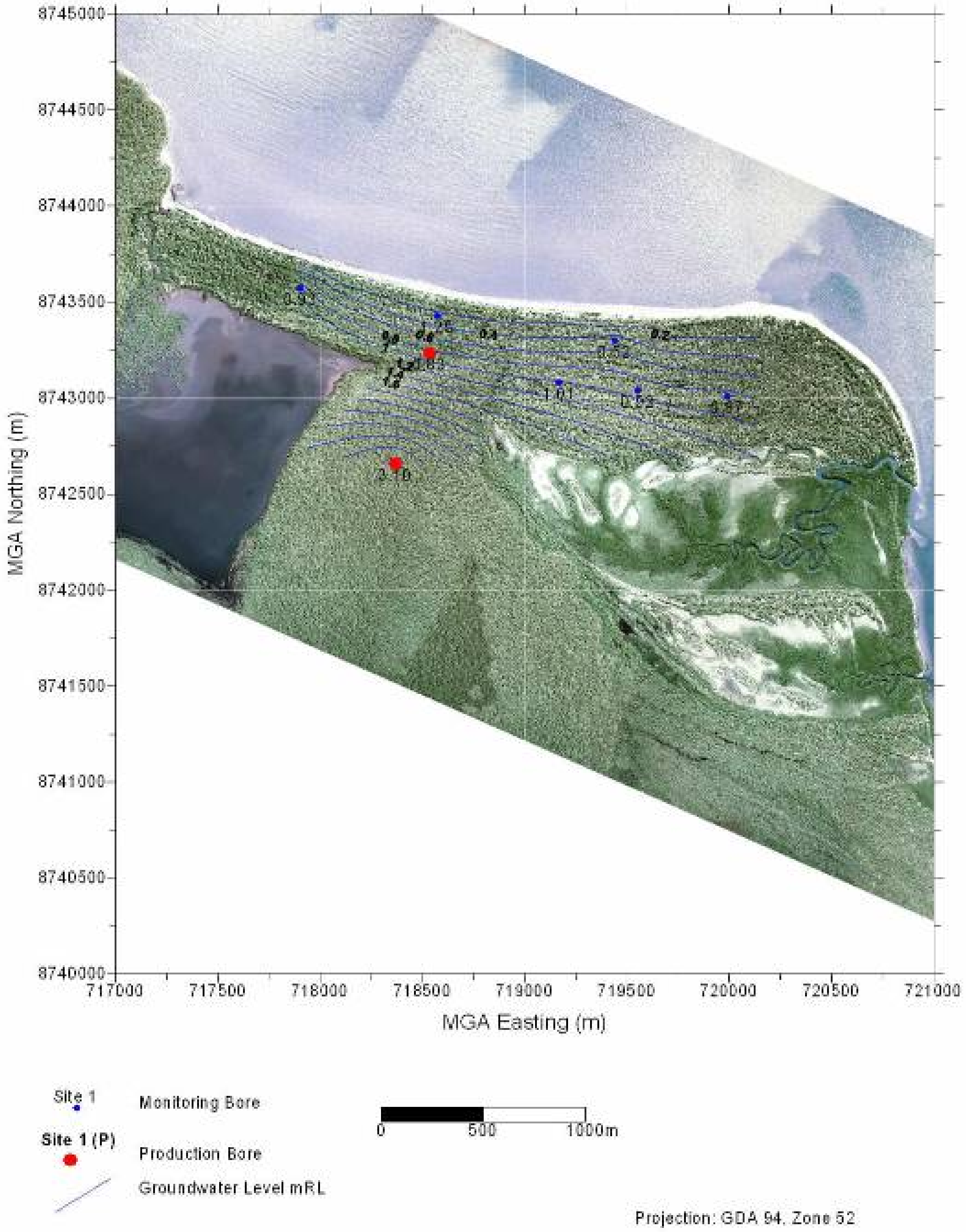


Figure 8.2
URS
Matilda Minerals
MINERAL SANDS PROJECT - DRAFT EIS
ANDRANANGOO
GROUNDWATER LEVELS DRY SEASON
Job No. 42213693
Prep. By CMAC 7 Sept. '05
Chk'd By RIJV 7 Sept. '05
Revision No. 0
Projection: GDA 94, Zone 52
MGA Easting (m)
MGA Northing (m)
Monitoring Bore
Site 1 (P)
Production Bore
Groundwater Level (m RL)
0
1000
2000m



			Matilda Minerals MINERAL SANDS PROJECT - DRAFT EIS **LETHBRIDGE GROUNDWATER LEVELS DRY SEASON**	**Figure 8.3**
Job No.	42213693			
Prep. By	CMAC	8 Sept. '05		URS
Chk'd By	RIJV	8 Sept. '05		
Revision No.	0			

Figure 8.3.srf

8.1.6 Groundwater chemistry

Andranangoo

Groundwater samples were collected from Site 1(P), Site 4(P), Site 7(P) and the Camp Bore near the end of pumping tests. The samples were dispatched for detailed laboratory analysis (Table 8.2).

Table 8.2 Recent Groundwater Analyses – Andranangoo Creek West

Analysis	Unit	Bore Number			
		Site 1(P)	Site 4(P)	Site 7 (P)	Camp Bore
pH		4.1	5.4	7.0	6.6
Total Dissolved Solids (TDS)	mg/L	248	78	151	58
Calcium	mg/L	<1	<1	35	2
Magnesium	mg/L	<1	<1	3	1
Sodium	mg/L	9	13	10	8
Potassium	mg/L	<1	<1	1	3
Sulphate	mg/L	<1	<1	2	<1
Chloride	mg/L	13	23	18	11
Nitrite	mg/L				<0.010
Nitrate	mg/L				<0.010
Arsenic	mg/L	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	<0.001	<0.001	0.001	0.003
Copper	mg/L	0.002	0.001	<0.001	<0.001
Lead	mg/L	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.004	0.006	0.055	0.143
Nickel	mg/L	<0.001	<0.001	<0.001	0.002
Silver	mg/L	<0.001	<0.001	<0.001	<0.001
Thorium	mg/L	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	<0.005	<0.005	<0.005	0.016
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001
Alpha Activity	Bq/l	0.08	0.12	0.07	-
Total Beta Activity	Bq/l	0.14	0.22	<0.1	-
K^{40} corrected Beta	Bq/l	0.13	0.21	<0.1	-

The sodium chloride groundwater is fresh, with laboratory salinities ranging from 58 to 248 mg/L TDS. Values of pH range from neutral at pH 7.0 to slightly acidic at pH 4.1.

The camp bore groundwater does not exceed the Australian Drinking Water Health Guidelines for analytes measured, however manganese is slightly higher than the aesthetic guideline value of 0.1mg/L.

Salinity profiles (conductivity measurements) were undertaken on selective bores to determine the salinity distribution with depth on the coastal plain.

Lethbridge

Groundwater samples were collected from the Camp Bore and near the end of the Site 9(P) pumping test, and were dispatched for detailed laboratory analysis (Table 8.3).

Table 8.3 Recent Groundwater Analyses – Lethbridge Bay West

Analysis	Unit	Camp Bore	Bore Site 9(P)
pH		5.8	7.6
Total Dissolved Solids (TDS)	mg/L	39	816
Calcium	mg/L	<1	80
Magnesium	mg/L	<1	16
Sodium	mg/L	8	206
Potassium	mg/L	<1	3
Sulphate	mg/L	<1	13
Chloride	mg/L	12	340
Nitrite	mg/L	<0.010	<0.010
Nitrate	mg/L	<0.010	<0.010
Arsenic	mg/L	0.002	-
Cadmium	mg/L	<0.0001	-
Chromium	mg/L	<0.001	-
Copper	mg/L	0.001	-
Lead	mg/L	<0.001	-
Manganese	mg/L	0.001	-
Nickel	mg/L	<0.001	-
Silver	mg/L	<0.001	-
Thorium	mg/L	<0.001	-
Uranium	mg/L	<0.001	-
Zinc	mg/L	0.010	-
Mercury	mg/L	<0.0001	-

The sodium-chloride groundwater is fresh with laboratory salinities ranging from 58 to 248 mg/L TDS and the pH (5.8) indicates that the groundwater is acidic.

The camp bore groundwater does not exceed the Australian Drinking Water Health Guidelines for analytes measured, however pH is lower than the aesthetic guideline value 6.5.

Salinity profiles (conductivity measurements) were undertaken on selective bores to determine the salinity distribution with depth on the coastal plain.

Groundwater is brackish to saline throughout all areas of the coastal plain due to seawater intrusion.

8.2 Objectives and standards

Matilda is committed to manage groundwater prior to the commencement, during and following the completion of mining activities at both the Andranangoo and Lethbridge sites. The objectives of this management will be to ensure potential negative impacts to the environment are prevented or minimised.

Matilda is also committed to conducting groundwater monitoring prior to the commencement, during and following the completion of mining activities at both the Andranangoo and Lethbridge sites. The monitoring will be used to ensure that potential negative impacts to the environment are prevented or minimised. The proposed monitoring will include groundwater levels and groundwater water quality.

Matilda will reference the NHMRC and NRMMC Australian Drinking Water Guidelines (2004) and the ANZECC Guidelines for Fresh and Marine Water Quality 2000 to assess the results of water quality sampling programs.

Relevant legislation, standards and policies

- Matilda's Environmental Policy (see Section 1.9.2 of this Draft EIS)
- *Mine Management Act 2001*
- *Soil Conservation and Land Utilisation Act 1985*
- *Waste Management and Pollution Control Act 1998*
- *Water Act 1992*
- *Water Supply and Sewerage Act 1988*
- ANZECC Guidelines for Fresh and Marine Water Quality 2000
- NHMRC and NRMMC Australian Drinking Water Guidelines (2004)

8.3 Definition of impacts and issues

8.3.1 Groundwater models

To asses the potential impacts from borefield supply, groundwater models have been developed.

Details of the models are presented in Appendix B.

Andranangoo

The model was calibrated to reproduce measured groundwater levels and flows, both regionally and during aquifer tests, i.e. the model can reasonably represent the conceptual hydrogeological model of the deposit and environs.

The model was calibrated in order to match simulated aquifer test drawdown to actual, and this produced a reasonably satisfactory calibration. Table 8.4 summarises the hydraulic parameters derived from the calibrated model, which broadly correspond with the values derived from the aquifer tests (Appendix B).

Table 8.4 Hydraulic Parameters Derived from the Andranangoo Calibrated Model

Layer	Formation/Lithology	Hydraulic Conductivity (Permeability)			Specific Storage	Specific Yield
		Kx	Ky	Kz		
		(m/d)	(m/d)	(m/d)	(1/m)	(-)
1	Superficial Sands	15	15	1	1e-3	0.25
2	Van Diemen Sandstone (upper)	20	20	0.005	1e-6	0.05
3	Van Diemen Sandstone (clay member)	0.01	0.01	0.001	1e-6	0.01
4	Van Diemen Sandstone (Ferruginous sandstone member)	12	12	0.2	1e-5	0.1
5	Moonkinu Member	0.001	0.001	0.0001	1e-6	0.01

Using the calibrated model, simulations of the borefield operation were undertaken based on the processing site mine water balance (Figure 8.4). Based on 90% return water from the dewatering cyclone, and a net loss of 360 kL/day from the tailings return water through seepage, the required bore groundwater supply is 840 kL/day. A camp water supply of 100 kL/day is also required. Based on these water requirements, the groundwater model was run for three years (anticipated mine life at Andranangoo). Duty rates for the simulated production bores are presented in Table 8.5.

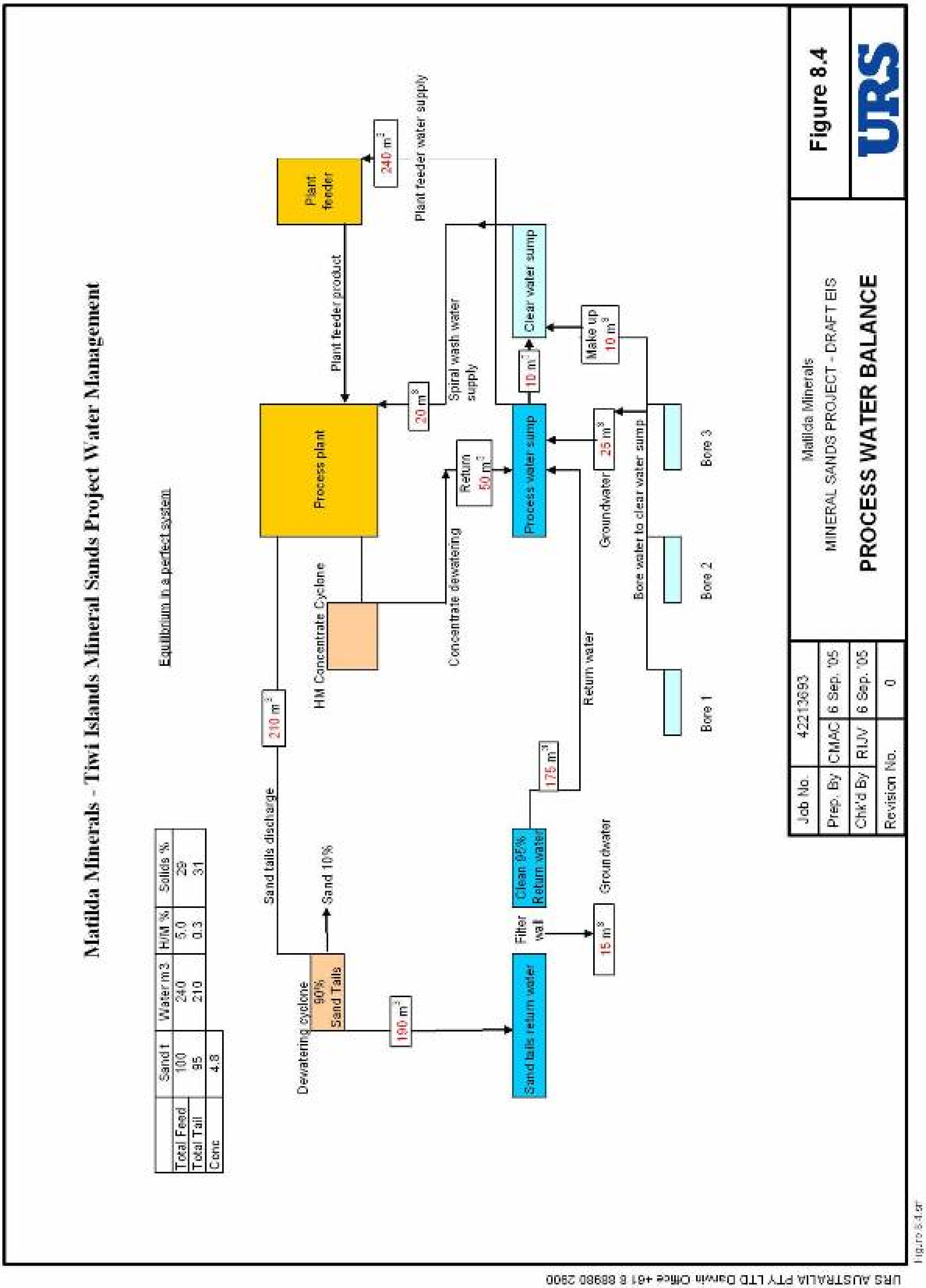

Matilda Minerals - Tiwi Islands Mineral Sands Project Water Management
Equilibrium in a perfect system
Sand t
Water m3
H/M %
Solids %
Total Feed
100
240
5.0
29
Total Tail
95
210
0.3
31
Conc
4.8
Plant feeder
240 m3
Plant feeder water supply
Plant feeder product
Process plant
20 m3
Spiral wash water supply
Clear water sump
Make up 10 m3
10 m3
Process water sump
Return 50 m3
25 m3
Groundwater
Bore water to clear water sump
Bore 1
Bore 2
Bore 3
HM Concentrate Cyclone
Concentrate dewatering
Return water
Sand tails discharge
210 m3
175 m3
Clean 95% Return water
Filter wall
15 m3
Groundwater
Sand 10%
Dewatering cyclone
90% Sand Tails
190 m3
Sand tails return water
Figure 8.4
URS
Matilda Minerals
MINERAL SANDS PROJECT - DRAFT EIS
PROCESS WATER BALANCE
Job No. 42213693
Prep. By CMAC 6 Sep. '05
Chk'd By RIJV 6 Sep. '05
Revision No. 0
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Table 8.5 Andranangoo Creek West - Simulated Bore Abstraction Rates

Bore	Simulated Rate (kL/day)
Site 1(P)	432
Site 4(P)	181
Site 7(P)	155
Camp Bore	173
Total	**941**

Lethbridge

The coastal plain at Lethbridge Creek West is saline. Thus, for environmental reasons, the bores for process water supply would be located within the Van Diemen Sandstone on the scarp, in areas where fresher permeable sediments would be located. This would minimise the potential for salinisation impacts in the mining area.

A future groundwater exploration programme will be required to locate prospective sites on the scarp. Based on calibrated model results at Andranangoo Creek West, a conceptual groundwater model was constructed to determine the likely drawdown associated with borefield operation.

Table 8.6 presents the parameters assigned to the model.

Table 8.6 Lethbridge Creek West Model - Hydraulic Parameters

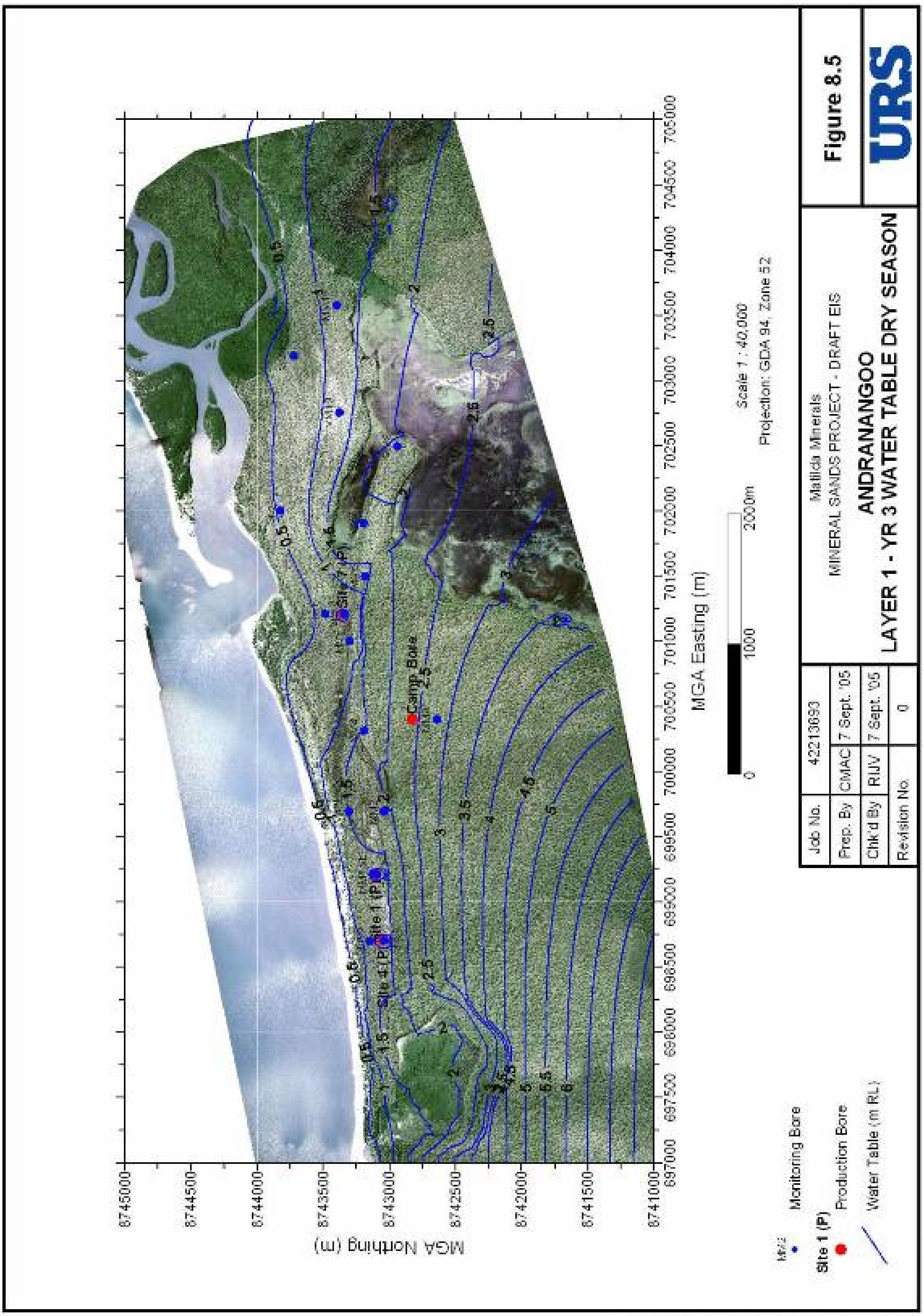
Layer	Kxy	Kz	Ss	Sy
Layer 1	20	0.005	1e-6	0.05
Layer 2	0.01	0.001	1e-6	0.05

8.3.2 Predicted drawdown from supply bores

Andranangoo

Figures 8.5 and 8.6 show the predicted water table elevations after three years of borefield operation, for both the dry and wet seasons. The groundwater levels show a groundwater gradient towards the coast, where groundwater levels are maintained above 0 m RL for both seasons.

Figure 8.7 show the predicted groundwater level drawdown in Layer 1 at the end of the dry season, after three years of borefield operation. The cone of depression is greatest near the production bores, where 0.4 m drawdown is observed, up to 100 m from the operational bores on the coastal plain. The limit of water table drawdown (less than 0.1 m) extends to the coast at the end of the dry season. The groundwater drawdown in Layer 3 (Figure 8.8) shows that the cone of depression (less than 0.1 m) does not reach the coast.



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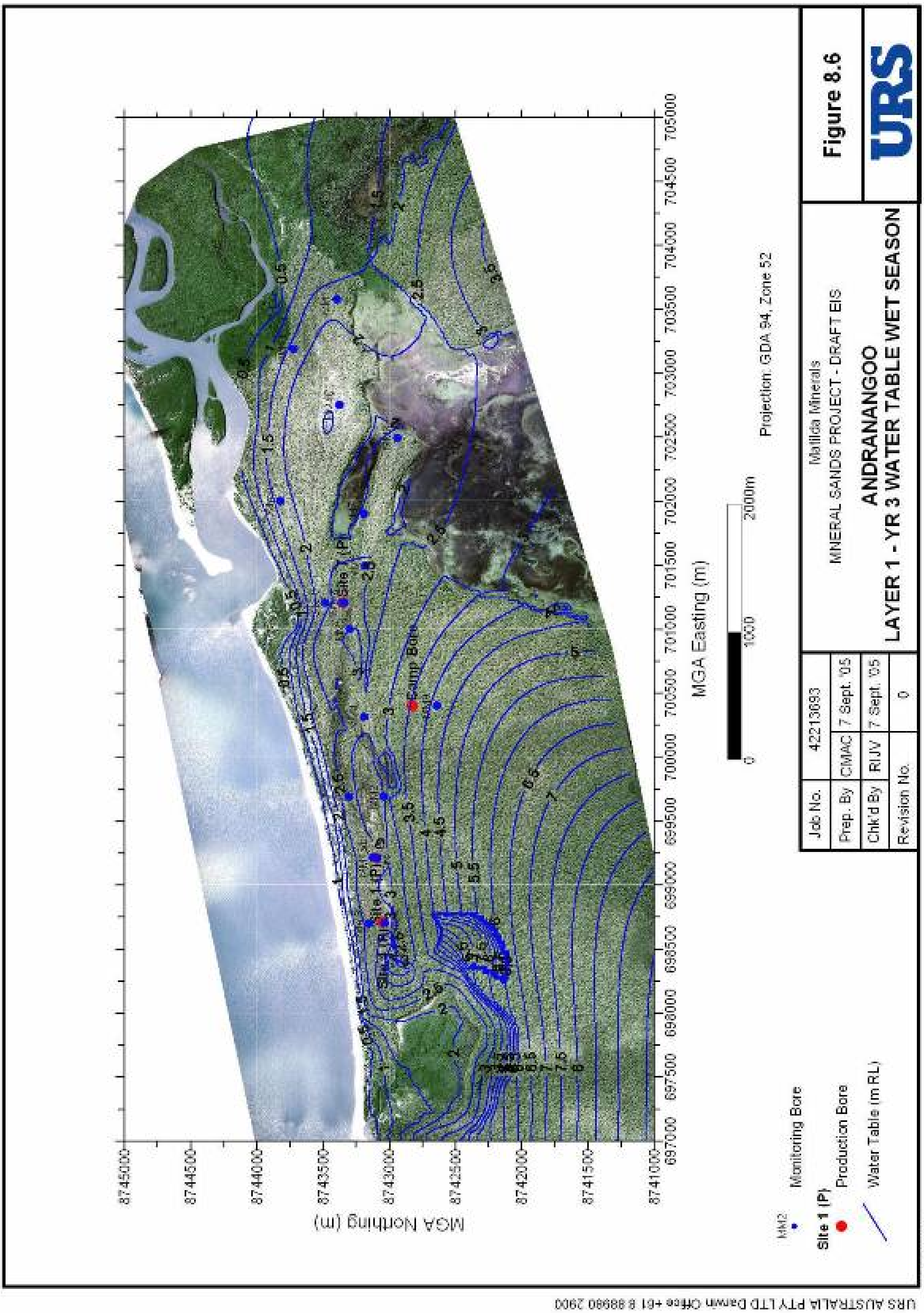
Figure 8.6
URS
Matilda Minerals
MINERAL SANDS PROJECT - DRAFT EIS
ANDRANANGOO
LAYER 1 - YR 3 WATER TABLE WET SEASON
Job No. 42213693
Prep. By CIMAC 7 Sept. '05
Chk'd By RIJV 7 Sept. '05
Revision No. 0
Projection: GDA 94, Zone 52
MGA Easting (m)
MGA Northing (m)
Monitoring Bore
Production Bore
Water Table (m RL)
Camp Bore
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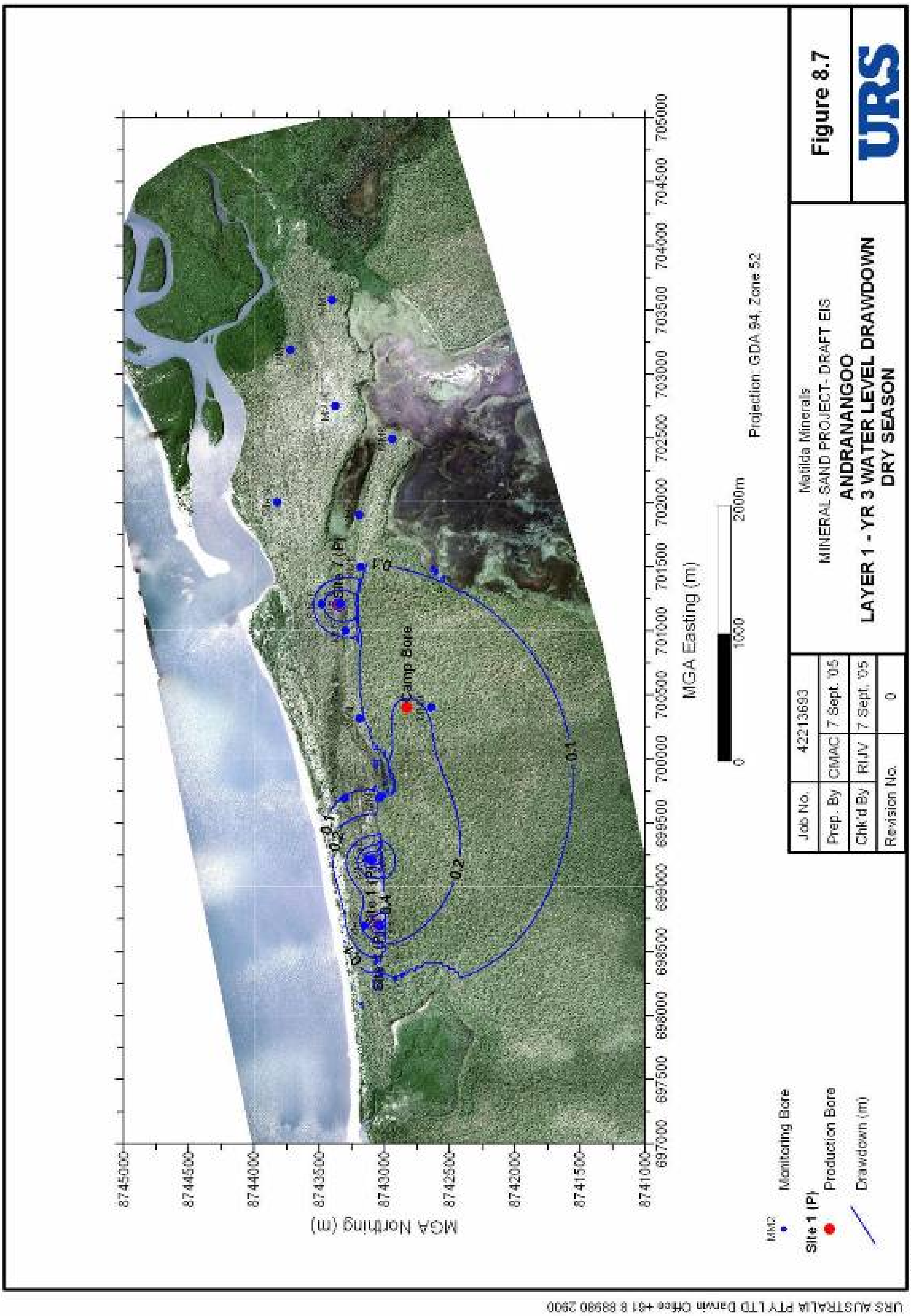
Figure 8.7
Matilda Minerals
MINERAL SAND PROJECT- DRAFT EIS
ANDRANANGOO
LAYER 1 - YR 3 WATER LEVEL DRAWDOWN
DRY SEASON
Projection: GDA 94, Zone 52
MGA Easting (m)
MGA Northing (m)
Camp Bore
Monitoring Bore
Production Bore
Drawdown (m)
Job No. 42213693
Prep. By CMAC 7 Sept. '05
Chk'd By RIJV 7 Sept. '05
Revision No. 0
0 1000 2000m
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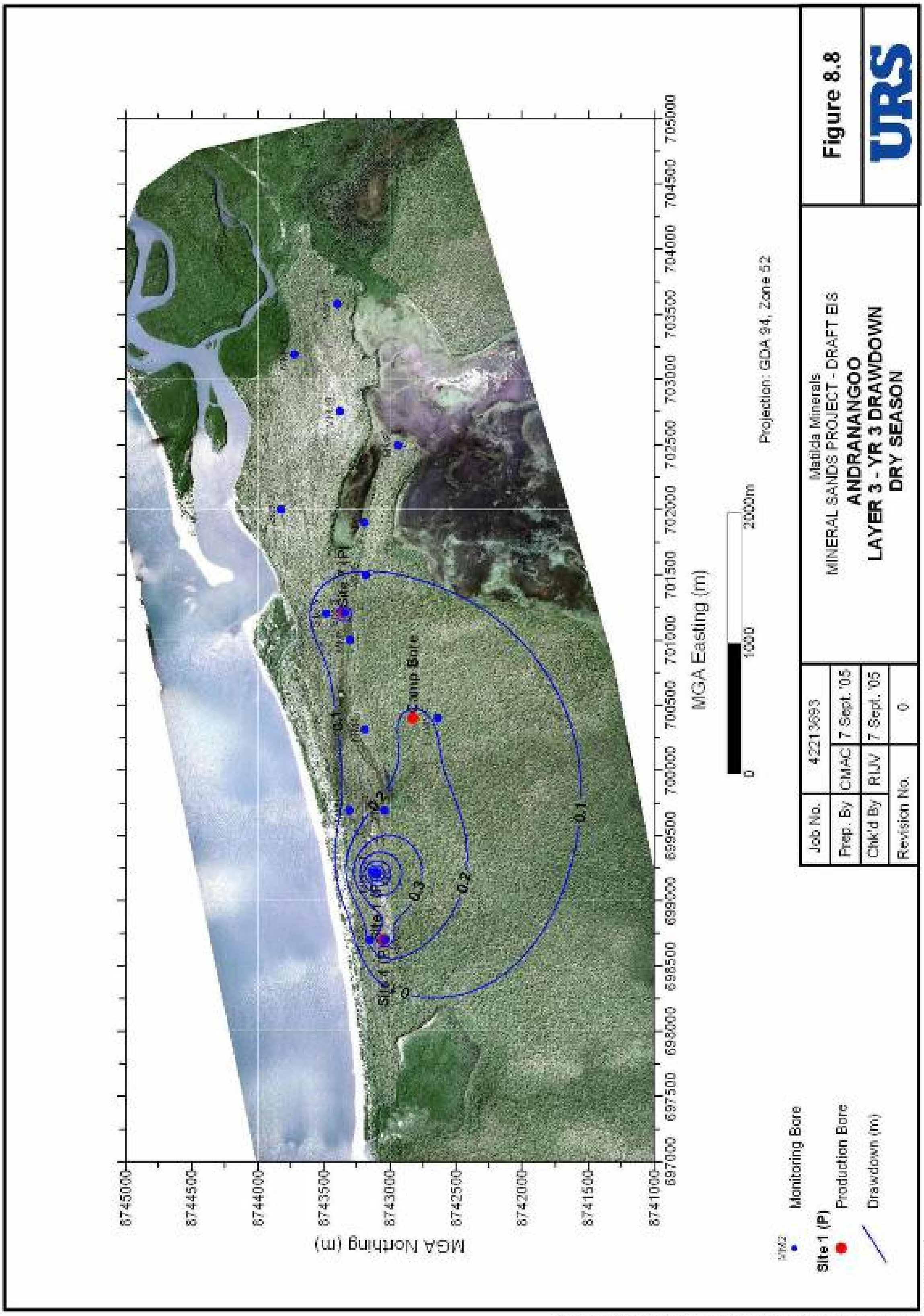

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Lethbridge

Simulations of the borefield operation were undertaken, based on the processing site mine water balance (Figure 8.4). Based on 90% returns from the dewatering cyclone and a net loss of 360 kL/day seepage from tailings return water, the required process bore groundwater supply is 840 kL/day.

Four production bores at a uniform spacing of 500 m, with abstraction rates of 200 kL/day per bore, were simulated from the Upper Van Diemen Sandstone. Abstraction for 365 days was simulated to determine predicted water table drawdown, although the mining operations are expected to last for only six months.

Figure 8.9 shows the extent of the drawdown, which is predicted to be 1.5 to 2 km from the borefield under the current modelled scenario. The groundwater level drawdown within 50 m of the production bores is likely to be between 0.9 and 1.6 m.

8.3.3 Groundwater drawdown impacts

Andranangoo

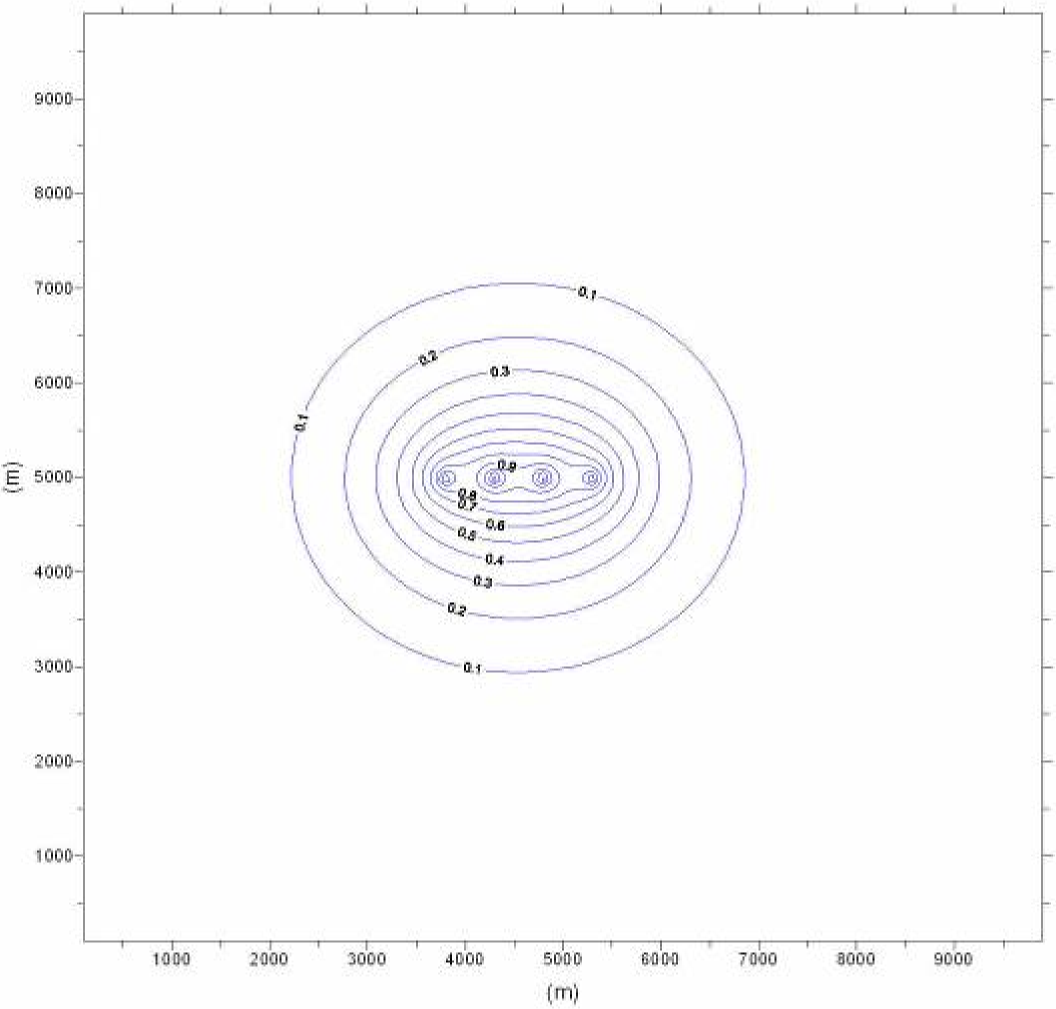
At the water table, the limit of drawdown at the end of dry season is located near the coast. As groundwater levels remain above sea level, and a groundwater gradient occurs between the scarp and the coast, it is unlikely that this drawdown will cause seawater intrusion into the sediments.

A perennial spring is located 150 m to the east of monitoring bore MM2. The predicted drawdown at this location is less than 0.1 m. A reduction in groundwater level of 0.1 m may result in a decrease in the depth and extent of the spring earlier in the dry season, before being replenished during the following west season when groundwater levels rise above ground surface.

Groundwater dependent ecosystems (GDEs) are those parts of the environment, in regard to the species composition and natural ecological processes, that are determined by the permanent or temporary presence of groundwater resources. For the purposes of defining ecosystem dependence on groundwater, groundwater is defined as water that has been below ground and would be unavailable to plants or animals were it to be abstracted by pumping. Ecological water requirements are defined as the water regime needed to maintain ecological values of water dependent ecosystems.

After the end of the wet season, the waterhole (near MM2) becomes a GDE as it depends on groundwater to maintain water levels. The modelling results indicate that a reduction in groundwater levels in unconfined aquifers can be expected to result in a decrease in the depth and extent of the spring at an earlier time in the dry season, prior to it being replenished in the following wet season. This is a temporary effect during mining only, and would rapidly recover following the cessation of mining.

Near the production bores, groundwater level drawdown may temporarily reduce the availability of groundwater to vegetation, typically near the end of the dry season, as groundwater levels are likely to be lower than historical levels. Again, there would be a rapid recovery following cessation of mining.



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Job No.	42213693		Matilda Minerals MINERALS SANDS PROJECT - DRAFT EIS	Figure 8.9
Prep. By	CMAC	22 Nov '05	**LETHBRIDGE** **SIMULATED GROUND WATER DRAWDOWN (m)**	URS
Chk'd By	RIJV	22 Nov '05		
Revision No.		0		

Figure 8.9.srf

Based on the preliminary modelling results, it appears that the groundwater-related impacts associated with mining will be minor and of short duration. Both proposed mining areas are underlain by a significant thickness of permeable sand deposits, which contain relatively large groundwater resources. Groundwater throughflow to the coast is significant, and it appears that the proposed groundwater abstraction associated with mining will not change this.

Simulated drawdown under a local perennial spring is less than 0.1 m during the dry season, and this will only impact the water level for a very short period at the end of the dry season.

Lethbridge

A prospective location for process water supply is located on the scarp, south of the mining area. The groundwater level drawdown is predicted to be about 1 m at a distance of 50 metres from the borefield. The extent of drawdown to a drawdown level of 0.1 m is likely to be between 1.5 and 2 km from the borefield. There would be a rapid recovery following cessation of mining, which, at Lethbridge, is expected to be only approximately six months.

More detailed modelling would be required to assess the impacts in more detail prior to mining and to determine the optimum location of the borefield. This modelling work would be undertaken following the proposed drilling program to be undertaken at the site. As groundwater levels are relatively deep on the scarp, impacts of reduced groundwater levels at the ground surface are not likely.

8.4 Management

3.1.1 Groundwater monitoring

The current groundwater monitoring network will used to meet environmental licensing guidelines associated with the borefield operation.

The requirements for groundwater monitoring could include:

- Monitoring fluctuations in groundwater levels,
- Monitoring of borefield abstraction,
- Monitoring of process water recovery rates, and
- Monitoring groundwater salinity variations between the coast and borefields.

8.5 Commitments

Matilda commits to monitoring of groundwater quality prior to commencement, during and following the completion of mining activities

Matilda commits to monitoring of groundwater levels fluctuations to assess any impacts of the borefield, especially in areas where a lowered water table could occur (Section 8.4.1)

Matilda commits to undertake more detailed modeling at Lethbridge to assess the impacts in more detail prior to mining, to determine the optimum location of the borefield.