Section 5 Groundwater

5.1 Regional Groundwater Systems

Six groundwater investigations of the Maud Creek deposits were undertaken to determine the hydrogeology and assist in designing a predictive groundwater flow model to assess the potential environmental impacts of underground mine dewatering. Previous groundwater investigations were undertaken in 1998 (Dames and Moore, 1998) to assess open-cut dewatering rates and determine potential groundwater impacts. Recent studies were undertaken to assess regional groundwater flow and groundwater/surface water interactions near Maud Creek.

Full details of the groundwater investigation undertaken for the EIS are given in Appendix B. This section summarises the results of that investigation.

5.1.1 Groundwater geology and aquifer occurrence

Local and regional groundwater flow is controlled by fracturing, surface weathering and alluvial sedimentation. Groundwater at the Maud Creek Deposit is located within fractured, weathered and oxidised tuff, particularly near the contact with the main quartz vein. The quartz breccia zone between the water table and about 100 m depth also forms a fractured rock aquifer. Groundwater may also be present at the interface and within the upper portion of the fresh tuff.

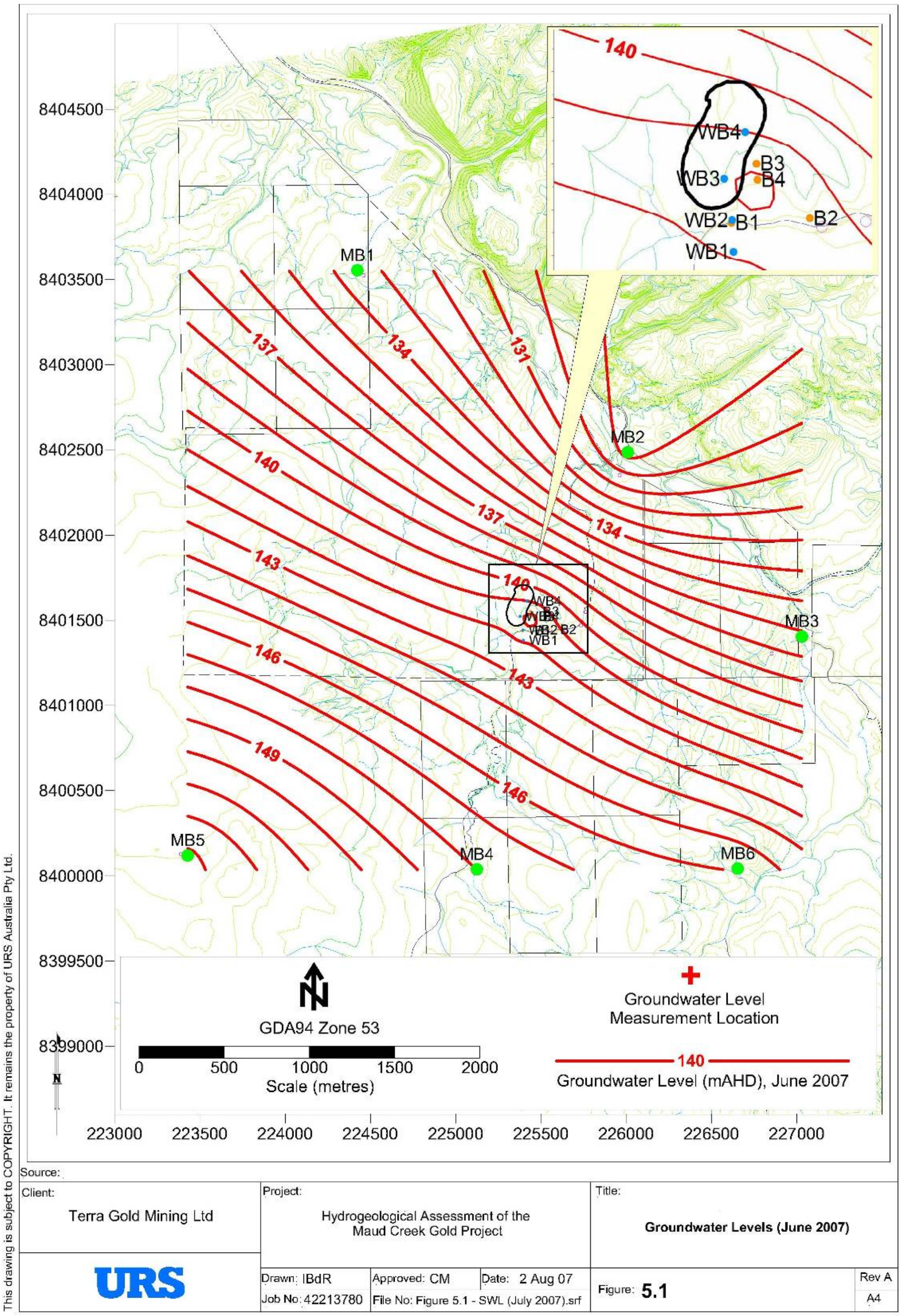
Recharge to the aquifers is from direct infiltration of rainfall, especially near the outcrop of the quartz and quartz breccia. Gold Creek is also a source of recharge to the local aquifers. Recharge to the aquifer is through infiltration of rainfall and some seepage through the river bed of Gold Creek.

5.1.2 Groundwater levels and flow

Groundwater levels in the Maud Creek area are between one and six metres below ground level, depending on topography. Groundwater flow is to the northeast, towards Maud Creek (Figure 5.1). Seasonal variations in groundwater levels are expected to be between two and four metres.

Regional groundwater yields are low, in the areas of unfractured Tollis Formation, Maud Dolerite, Antrim Plateau Volcanics. Regional drilling indicates low airlift yields up to 100 kL/day (MB6). Yields are higher where cavernous limestone or fractured rock is intersected, with yields up to 500 kL/day being reported (MB5). Locally, within the Maud Creek Deposit, groundwater yields of up to 1,200 kL/day are reported (Dames and Moore, 1998).

Figure 5.1 Ground Water levels (June 2007)



5.1.3 Groundwater chemistry

Groundwater at the Project site and surrounding regions is fresh, with total dissolved solids (TDS) concentrations ranging from 320 mg/L (MB4) to 636 mg/L (MB1) (Table 5.1).

The groundwater is calcium/magnesium bicarbonate type, with a chemical composition typical of recently recharged groundwater. The pH of groundwater is slightly alkaline with pH values ranging between 7.87 (MB5) and 8.19 (MB4).

In comparison with the Australian Drinking Water Guidelines 2004, groundwater quality exceeded aesthetic guideline values for total dissolved solids and bicarbonate, and health guideline values for selenium (WB3) and arsenic for all bores sampled except for MB2 and MB5.

Table 5.1 Groundwater Analyses

Analyte/Parameter	Units	WB3	MB1	MB2	MB3	MB4	MB5	MB6	Drinking water guideline
pH	-	-	7.90	6.95	8.11	8.19	7.87	8.01	6.5-8.5*
Electrical Conductivity	µS/cm	1,086	903	728	622	564	806	850	-
Total Dissolved Solids	mg/L	515	636	502	434	320	462	528	500*
Calcium	mg/L	54	19	53	45	38	82	58	-
Potassium	mg/L	2.9	12	7	8	9	4	18	-
Magnesium	mg/L	53	16	72	66	36	60	70	-
Sodium	mg/L	13	206	29	19	32	8	28	180*
Carbonate	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-
Bicarbonate	mg/L	521	331	458	356	264	466	448	200*
Chloride	mg/L	10	134	9.3	7.4	9.7	4.7	10.0	-
Sulphate	mg/L	3.4	16	28	60	40	5	50	250*
Nitrate	mg/L	0.05	-	-	-	-	-	-	50
Silicon	mg/L	48	-	-	-	-	-	-	-
Iron (total)	mg/L	0.036	-	-	-	-	-	-	0.3*
Iron (filtered)	mg/L	-	<0.05	<0.05	0.09	<0.05	<0.05	<0.05	0.3*
Arsenic (total)	mg/L	0.018	-	-	-	-	-	-	0.007
Arsenic (filtered)	mg/L	-	0.009	0.006	0.012	0.018	0.003	0.011	0.007
Cadmium (filtered)	mg/L	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002
Chromium (filtered)	mg/L	-	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	0.05
Copper (filtered)	mg/L	-	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	2
Selenium (filtered)	mg/L	0.033	-	-	-	-	-	-	0.01
Barium (filtered)	mg/L	0.25	-	-	-	-	-	-	0.7
Lead (filtered)	mg/L	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01
Nickel	mg/L	-	<0.001	0.001	0.001	<0.001	<0.001	0.002	0.02
Zinc	mg/L	-	<0.005	<0.005	0.012	<0.005	0.007	<0.005	3*

* - Aesthetic Guideline
Shaded areas indicated exceeding health or aesthetic guideline values

5.2 Definition of impacts and issues

5.2.1 Groundwater model

A groundwater model was derived to asses the potential impacts from underground mine dewatering. Details of the model are presented in Appendix B.

The groundwater model was calibrated to reproduce groundwater levels and flow at regional and local scales such that the model can reasonably represent the conceptual hydrogeological model of the deposit and surrounding region. Previous aquifer testing (Dames and Moore, 1998) was used to assist with model calibration which produced a reasonably satisfactory calibration. Table 5-2 summarises the hydraulic parameters derived from the calibrated model, which broadly correspond with values derived from the aquifer tests (Appendix B).

Table 5.2 Hydraulic Parameters Derived from the Calibrated Model

Unit	Revised Model				Dames and Moore (1998)			
	K_{XY}	K_Z	Ss	Sy	K_{XY}	K_Z	Ss	Sy
Other (Proterozoic)	0.0001	0.0001	0.001	5.0E-06	-	-	-	-
Ore Host Rock (Tuffs)	0.002	0.002	0.001	5.0E-06	0.002	0.002	0.0005	1.0E-06
Tindal Limestone	10	10	0.2	2.0E-06	-	-	-	-
Ore Zone	2	2	0.001	1.5E-04	0.1 - 3	0.1 - 2	0.001 - 0.1	1.0E-06
Weathered Layer	0.06	0.06	0.025	5.0E-06	1	1	0.2	1.0E-06
Alluvial Sediments	0.5	0.5	0.2	5.0E-06	-	-	-	-

K_{XY} Horizontal Hydraulic Conductivity (m/day)
K_Z Vertical Hydraulic Conductivity (m/day)
Ss Specific Storage (dimensionless)
Sy Specific Yield (dimensionless)

To assess the anticipated extent of groundwater drawdown over the life of mine, and groundwater inflow rates, the underground mine development schedule was incorporated and the underground mine dewatering was simulated, using the calibrated model.

5.2.2 Underground mine dewatering rates

Mine dewatering is required to stop the ingress of groundwater into the underground mine workings. The groundwater model has been used to estimate the extent of mine dewatering requirements. The proposed underground mine schedule is to be developed over a 10 year mine life, and this mine life has been included in the groundwater model to simulate the groundwater abstraction from the dewatering system.

The estimated total groundwater inflow rate for the first year is estimated at about 3,400 kL/day, with groundwater inflows progressively decreasing to 1,700 kL/day by the end of mining.

5.2.3 Predicted drawdown from underground mine dewatering

Figures 5-2 and 5-3 show the predicted water table elevations after 2 and 10 years of underground mine dewatering.

Figure 5-2 show the predicted groundwater level drawdown at the end of the dry season after two years of underground mine dewatering. The cone of depression is greatest at the mine, and the extent of the 1 m drawdown is observed up to 1.1 km from the mine.

Figure 5-3 show the predicted groundwater level drawdown at the end of the dry season, after 10 years of underground mine dewatering. The cone of depression is greatest at the mine and the extent of the 1 m drawdown is observed up to 1.8 km from the mine.

As shown in Figures 5-2 and 5-3, the drawdown effects are quite localised, even at the end of the expected 10 year mine life. At the completion of mining, and cessation of dewatering, groundwater levels are expected to recover quickly outside of the immediate underground mine area.

5.2.4 Groundwater drawdown impacts

Drawdown caused by underground dewatering has the potential to lower groundwater levels near Gold Creek within the first two years of mining, and potentially Maud Creek in the longer term. As a result, in areas where hydraulic connection exists between the creeks and underlying aquifers, there is a potential for reduced creek flows during the early and late wet season, November – December and April – May due to groundwater drawdown.

However, during these periods, the flow in Gold Creek will rely more on groundwater discharge from the predominantly limestone aquifers in the upper part of the Gold Creek catchment rather than the local aquifer system at the mine. Groundwater levels in other areas of Gold Creek are generally below ground surface during the dry season, and provide insignificant 'seepage' flow in the creek.

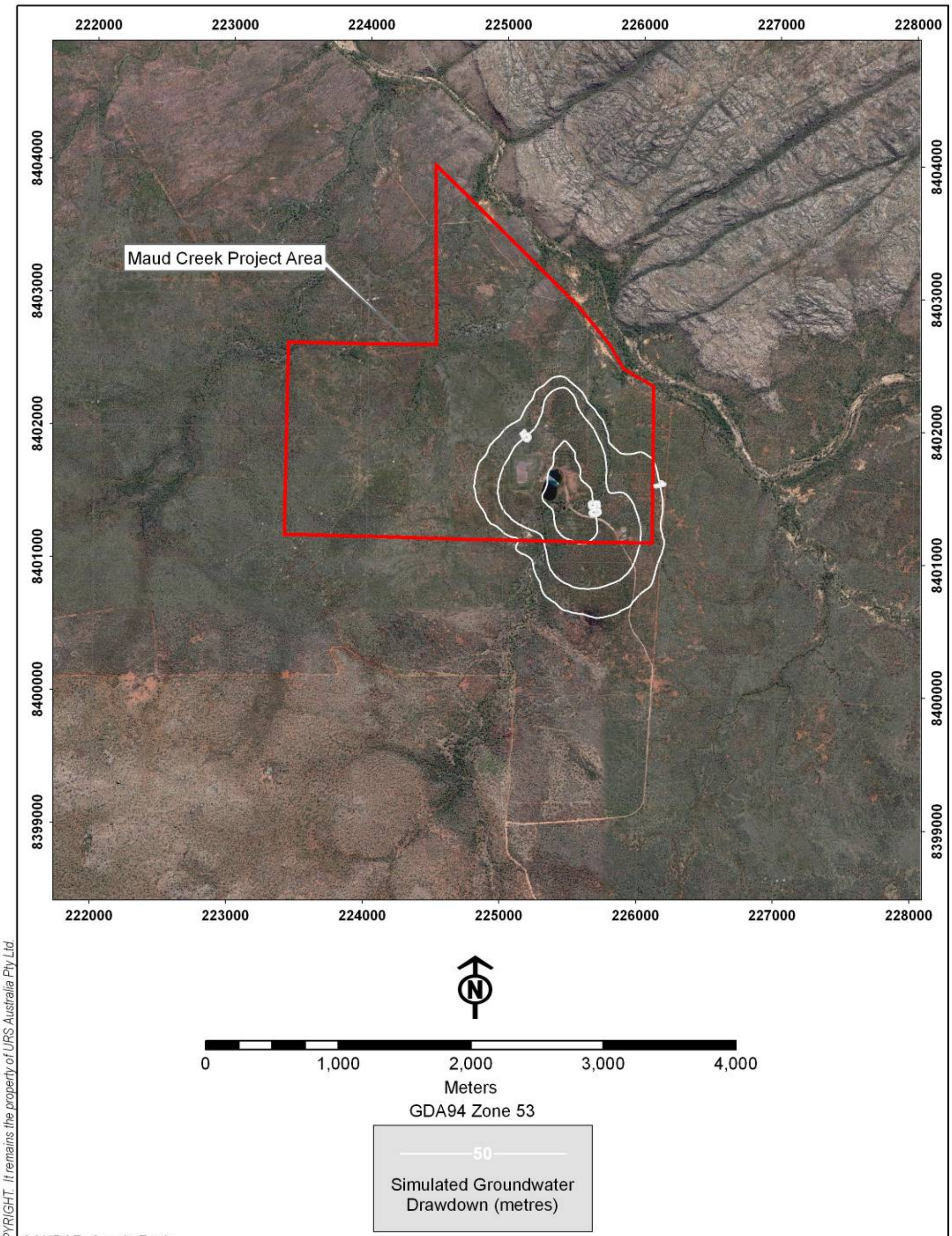
Flow in Maud Creek is also seasonal, with low or no flow during the dry season. During the dry season, flows are reported to be from upstream discharges. Similarly, for Maud Creek there is a potential for reduced creek flows during the shoulder stream flow periods in November – December and April – May due to groundwater drawdown at Maud Creek mine.

The groundwater level at the confluence of Gold and Maud Creek (MB2) is approximately 6.9 m below ground level (approximately 4 m below the creek bed) in the dry season. Maud Creek is underlain here by a thin alluvial section, clayey sand, sandstone, greywacke and dolerite. Groundwater yield from bore MB2 was very low at 1.7 kL/day, indicating very low permeable strata. Since groundwater levels are below the base of Maud Creek and the strata is likely to be of very low permeability, the lowering of the groundwater table is unlikely to cause significant changes in creek flow.

Groundwater drawdown has the potential to reduce the availability of water to support woodland vegetation when groundwater levels are naturally within 5 m of the ground surface. As groundwater levels are generally between 1 and 6 m below ground surface, it is likely that some vegetation may be affected by a reduction in available water within the drawdown cone of the mine dewatering system. However, due to the laterally confined nature of the mine aquifer, and the short mine life, the impact will be very limited in space and time.

No beneficial use of groundwater for agriculture or domestic supply has been identified within the predicted drawdown extent. Neither are there any permanent pools or soaks within the predicted drawdown extent that would have beneficial uses for the environment.

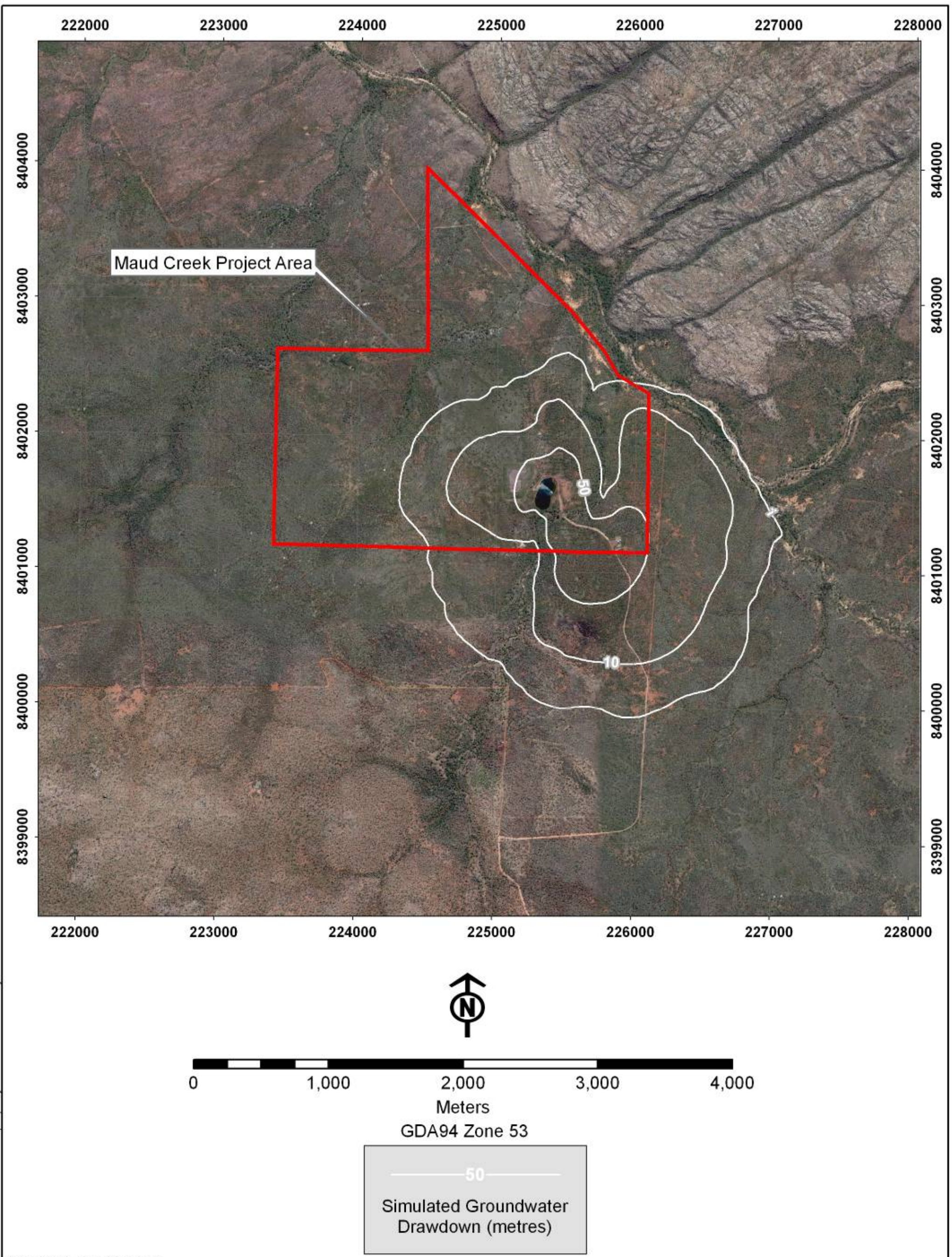
Figure 5.2 Simulated Groundwater Drawdown – year 2



SOURCE: Google Earth

Client	Project	Title
Terra Gold Mining Ltd	MAUD CREEK GOLD PROJECT	Simulated Groundwater Drawdown Year 2
URS	Drawn: JD; Approved: CM; Date: 2 Aug 07; Job No.: 42213775; File No.: 42213775-052.mxd	Figure: 5.2; Rev. A; A4

Figure 5.3 Simulated Groundwater Drawdown – year 10



SOURCE: Google Earth

Client	Project	Title
Terra Gold Mining Ltd	MAUD CREEK GOLD PROJECT	Simulated Groundwater Drawdown Year 10
URS	Drawn: JD / Approved: CM / Date: 2 Aug 07 / Job No.: 42213775 / File No.: 42213775-053.mxd	Figure: 5.3 / Rev. A / A4

5.2.5 Groundwater Management Zone impacts

Figure 5-4 shows the mine site and irrigation area with respect to existing bores. Figure 5-5 shows the mine site with respect to the groundwater management area. The groundwater management area is located on the southern portion of the irrigation area, however it is planned that a 42 ha centre pivot will be located in the northern portion, outside but adjacent to the groundwater management area.

Figure 5-5 also shows a section line in plan view between Maud Creek and a single Tindal aquifer bore; an inferred section view is presented in Figure 5-6. The section shows the inferred sandstone/greywacke lithology near the vicinity of Maud Creek and limestone underlying the irrigation area overlain by clay and sand. Groundwater levels are highest within the sandstone/greywacke units and progressively decrease towards the south. Basalt intrusions occur along the boundary of the limestone and greywacke/sandstone and groundwater levels may vary locally from the inferred level as a consequence. Irrigation in excess of evapotranspiration (deep drainage) will recharge to the underlying aquifers.

Arsenic (As) is identified in Table 5-1 as the principal contaminant of concern in relation to the protection of water supplies and animal health. The monitored water quality from potential input sources to the irrigation system has arsenic concentrations ranging from 0.037 mg/L in the pit lake, to 0.003 mg/L at bore MB5. These concentrations may vary with advanced dewatering of the underground mine.

However, the soils in the irrigation area are deep sandy Red Earths, and these lateritic soils are very efficient in removing both arsenite and arsenate from aqueous solution (irrigation water) by adsorption. Maji *et al*. (2007) measured removal up to 98% of arsenite, and 95% of arsenate, in batch adsorption experiments conducted at 0.5 mg/L initial concentration of arsenic. The published adsorption figures and the exponential kinetic profiles for removal give assurance that the possibility of declining water quality is unlikely to be a critical issue affecting adsorption to the soil.

The risk that water flow paths could by-pass the adsorption surface provided in the soil matrix, and move rapidly to groundwater without time for the adsorption reaction, is low. This is because the massive and earthy fabric and iron mineralogy of the soils in the irrigation area promote matrix flow and diffusion films, which a strong adsorption reaction relies upon. In practice, sandy media coated with iron oxides have been used to polish arsenic contamination from groundwater (Gupta & Vaishya, 2006).

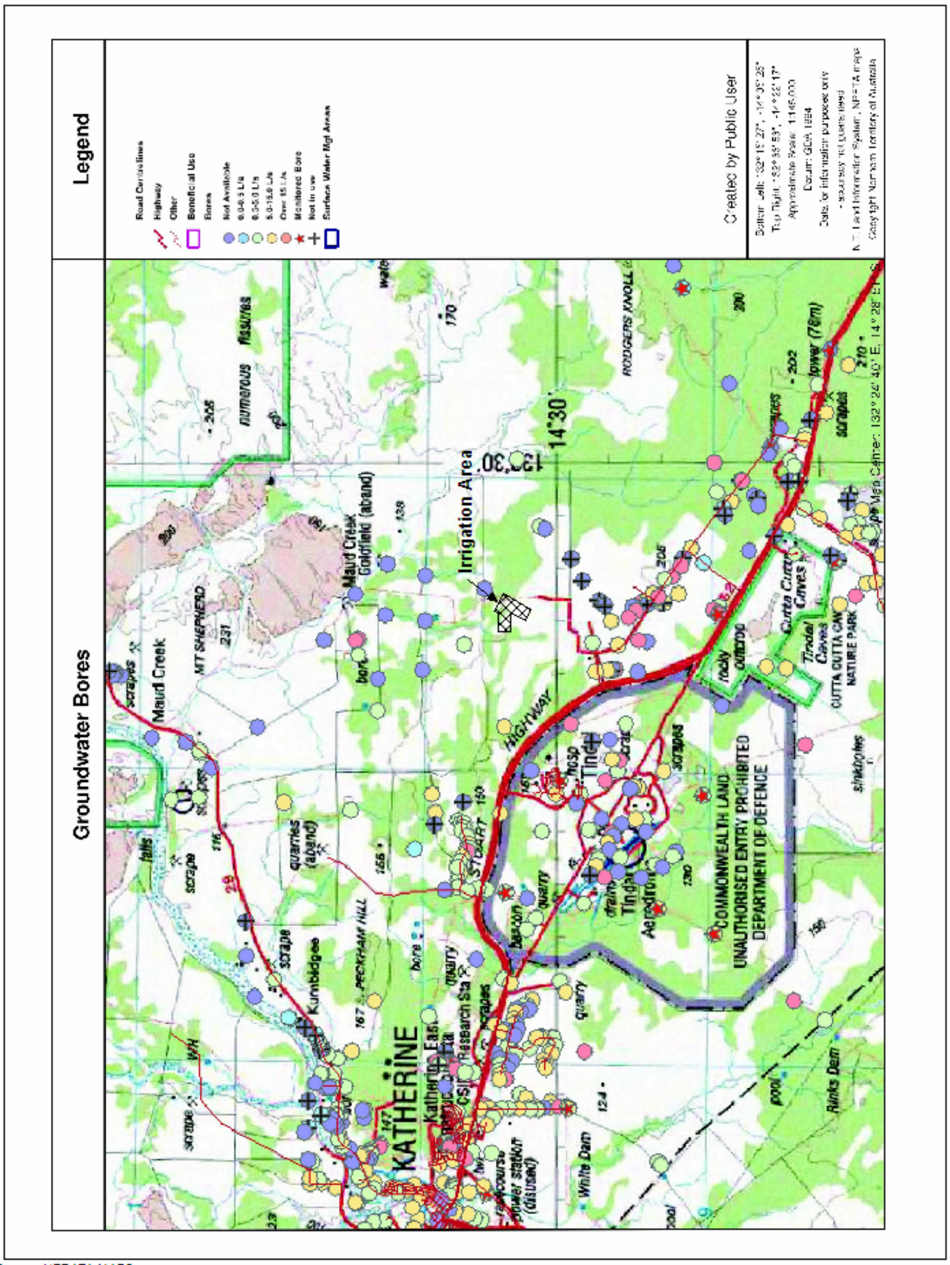
The assessment of the soil depth needed to adsorb applied arsenic in the irrigated groundwater over the life of the mine is based on the following assumptions:

- The centre pivot irrigation unit irrigates 42 ha;
- Soil bulk density assumed to be 1,400 kg/ m^3;
- Maximum desirable arsenic concentration of 100 mg As/kg soil is required (=140 g/m^3: Category A health investigation level suitable for standard residential soil NEPC, 1999);
- 1 GL (1,000,000,000 L) groundwater to be irrigated per year;
- Assume arsenic concentration in groundwater is 50 μg/L;
- Annual load of arsenic is 1 GL x 50 μg/L = 50 kg;
- Application of 50 kg As to 42 ha will yield 0.85 mm of soil profile with arsenic concentration of up to 100 mg/L; and
- Application of this rate over ten years will yield 8.5 mm of soil profile with arsenic concentration of up to 100 mg/L.

In practice, the depth of soil containing arsenic may differ (shallower if the arsenic is taken up at a greater rate and deeper if it is removed at a lesser rate), but these calculations demonstrate that the depth of slightly elevated concentration of arsenic in soil will be very minor. It must be noted that arsenic which is bound to soil particles will no longer be available for dissolution to water and thus will not be able to migrate to groundwater. Based on this assessment, the risk of arsenic impact on groundwater from the irrigation area operation is judged to be negligible. However, considering the human health concern associated with arsenic, and the extreme negative public perception of potential for water contamination from mining land use, a commitment to quantifying the adsorption and mobility of As in the irrigated soil at the site, and demonstrating the validity of the predicted distribution of arsenic in the soil via a monitoring program, is justified.

Section 5 Groundwater

Figure 5.4 Existing Groundwater Bores



Source: NREATA MAPS

Client: Terra Gold Mining Ltd	Project: MAUD CREEK GOLD PROJECT		Title: Existing Groundwater Bores
URS	Drawn: IBdR / Job No: 42213775	Approved: CM / File No: Figure 5.4.srf	Date: 2 Aug 07
		Figure: 5.4	Rev A / A4

Figure 5.5 Groundwater Management Area

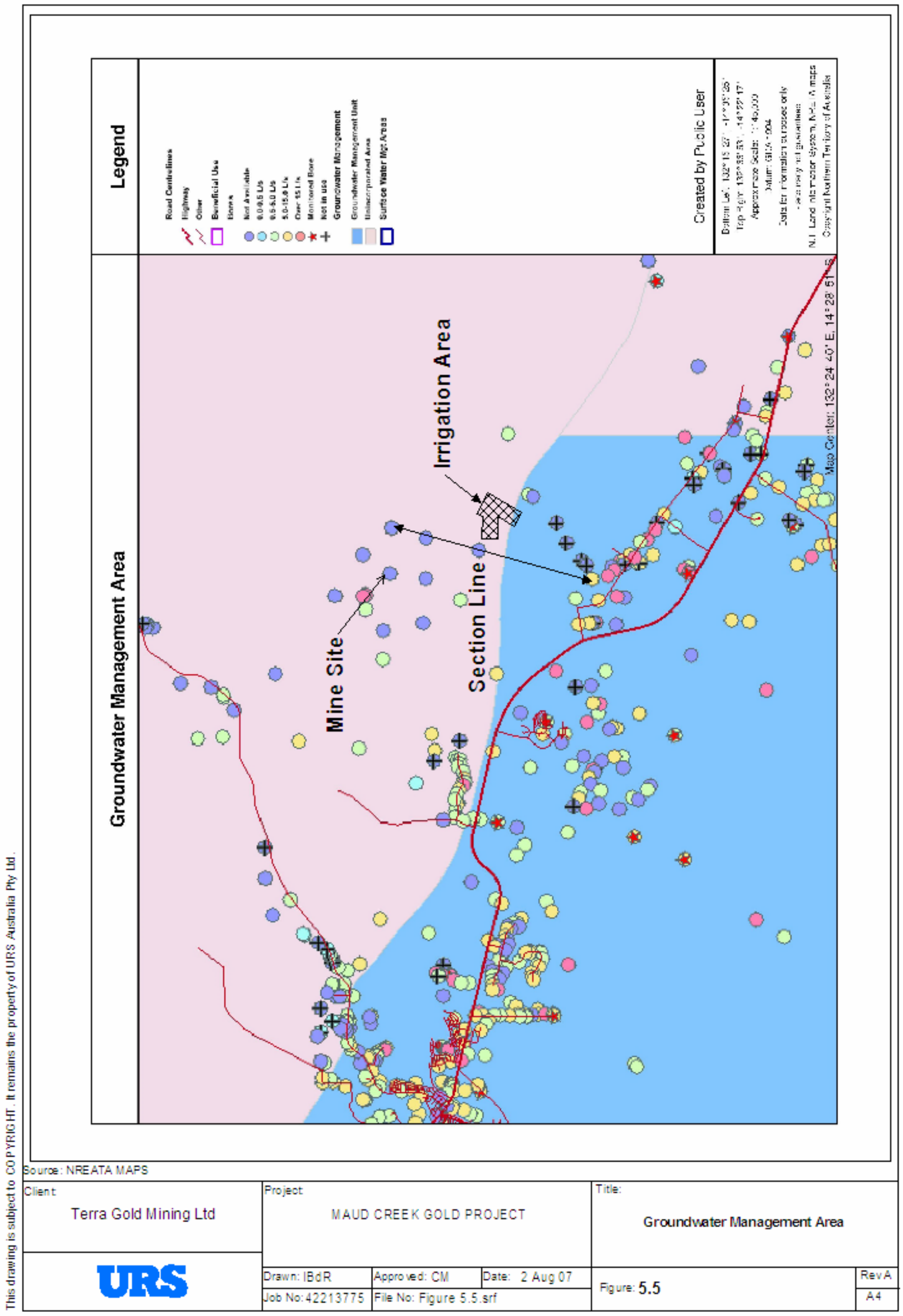
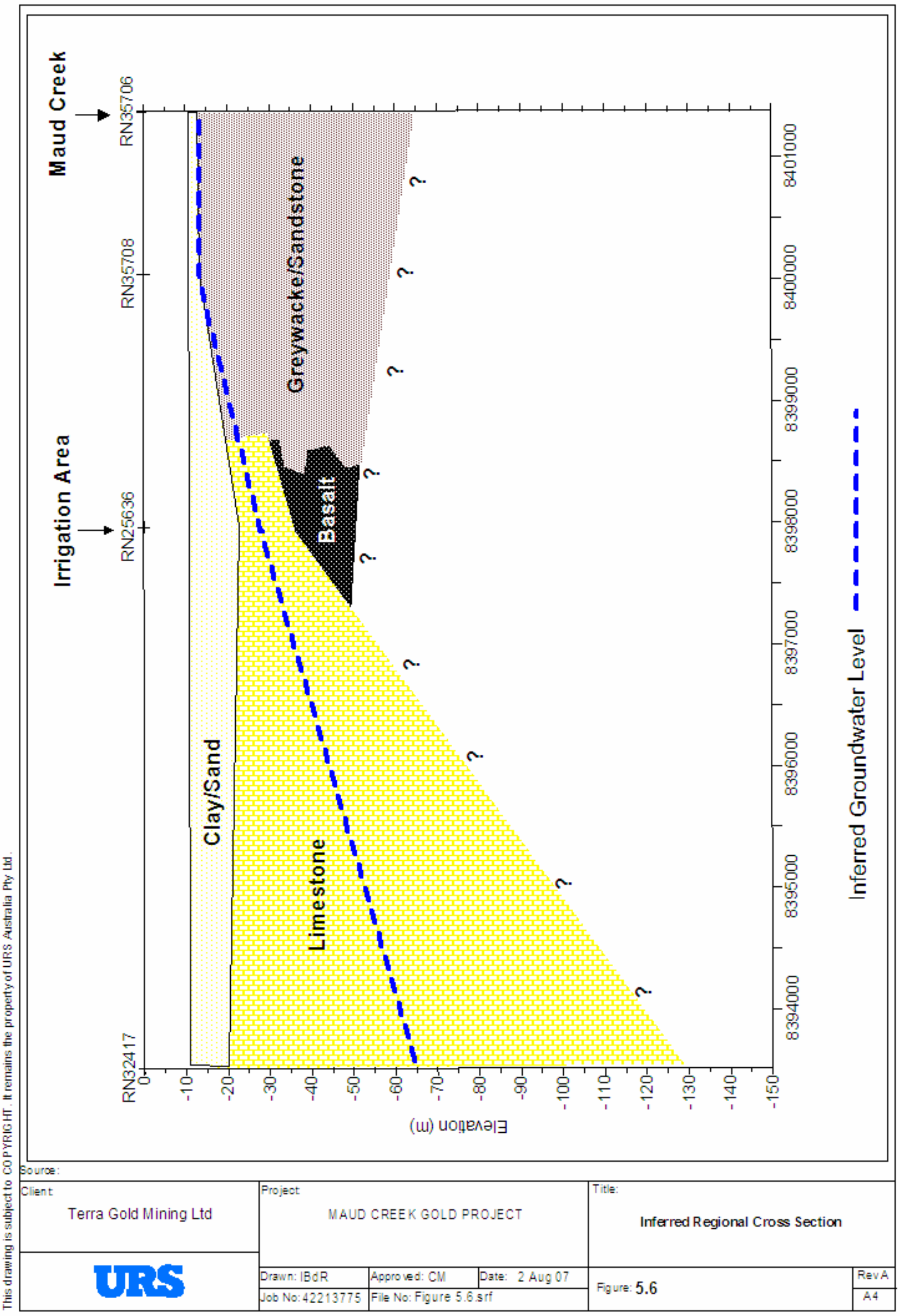


Figure 5.6 Inferred Regional Cross Section



5.3 Groundwater Management

The current groundwater monitoring network will be used to meet environmental licensing guidelines associated with mine dewatering and irrigation requirements.

The groundwater monitoring is proposed to include:

- Monitoring fluctuations in groundwater levels;
- Monitoring of underground mine dewatering abstraction; and
- Monitoring of underground mine dewatering abstraction quality.

In addition, as noted above, the soil of the irrigation area would also be monitored to assess any impacts arising from irrigation of groundwater arising from mine dewatering.

5.4 Commitments

Terra Gold commits to monitoring groundwater quality prior to commencement, during and following completion of mining activities.

Terra Gold commits to monitoring of groundwater levels fluctuations to assess any impacts of the underground mine dewatering, especially in areas where a lowered water table could occur.

Terra Gold commits to monitoring of groundwater levels fluctuations to assess any impacts of the irrigation area.

Terra Gold commits to monitoring of soil and groundwater quality to assess any impacts of the irrigation area, in particular in relation to arsenic levels.