11. Hydrogeology

11.1 Introduction

This Chapter provides a summary of the key findings of hydrogeological assessments undertaken to support the redevelopment of the Mt Todd Gold Mine. This chapter:

- defines the existing hydrogeological conditions of the mine site;
- details additional field work and analysis carried out to address data gaps;
- describes conceptual hydrogeological models for the area;
- details numerical groundwater flow modelling of current and proposed conditions at the site;
- assesses potential impacts of the mine on groundwater resources, including contamination of groundwater, changing of watertables, inflow of groundwater to the pit and post-mining pit water levels; and
- outlines management and monitoring measures.

A detailed hydrogeological assessment is provided in Appendix K. The potential impacts and associated mitigation measures identified in this chapter form the basis of the groundwater component of the project risk assessment undertaken in Chapter 5. The project risk assessment includes consequence, likelihood and residual risk ratings for groundwater impact after management measures are implemented.

11.2 Background

Data collation, field investigations and conceptual model development was performed by GHD in 2011-12, along with a preliminary groundwater model. A revised numerical model was developed in 2013 by Tetra Tech to assess mining and post mining groundwater impacts associated with changes to the Project (Appendix K). Unless otherwise stated, information in this Chapter is drawn from this 2013 report.

The Mt Todd Gold Project has several proposed aspects that are relevant to hydrogeology:

- extension of the existing Batman Pit from its current depth of 114m to approximately 588m (RL 396m) and surface area of 40ha to approximately 137ha;
- expansion of the existing WRD from a height of 24m to approximately 350m (RL 470m), and a footprint of 70ha to approximately 217ha;
- raising the existing tailings storage facility (TSF1) by 18m to a final height of 34m;
- the RWD which will be raised by 2m; and
- construction of a new TSF2, approximately 300m in area and up to 60m high.

11.3 Existing Environment

11.3.1 Location

The Mt Todd mine site is located approximately 55km north-west of Katherine. The site is immediately north of the Edith River, which flows west into the Ferguson River and on to the Daly River (Figure 10-1). The Edith River drains off a low plateau (the Arnhem Plateau) to the east of the site at Leliyn (Edith Falls), in the Nitmiluk National Park. Below Leliyn, the Edith River is fed by numerous ephemeral creeks that flow out of the low rocky ridges, including creeks that traverse the mine site. Creeks that traverse the mine site include Batman and Horseshoe creeks, which flow into Stow Creek. Stow Creek enters the Edith River upstream of Burrell Creek and West Creek (Figure 10-11).

11.3.2 Climate Summary

Precipitation

Rainfall data from the Katherine weather station (BOM Station No. 014902) along with recent climate data (including observations during the study year) from the additional BOM site at Edith Falls Ridge and the DLRM station on the Fergusson River upstream of Bondi Creek were used in this study. Rainfall was recorded at the Mt Todd mine from 1993-2006 and 2008-2012.

Mean monthly rainfall for the mine site and the Katherine station, for the same period, are shown in Figure 11-1. Annual precipitation measured at the site is 1,355mm compared with 1335mm at Katherine. Point source annual average precipitation for Batman Pit is 1,057.09mm (GA-CSIRO 2012).

Rainfall is locally variable, both spatially and seasonally, with a pronounced Wet Season from October through to April and a Dry Season from May to September. Large Wet Season rainfall events are generally associated with low pressure systems including, but not limited to, ex-tropical cyclones.

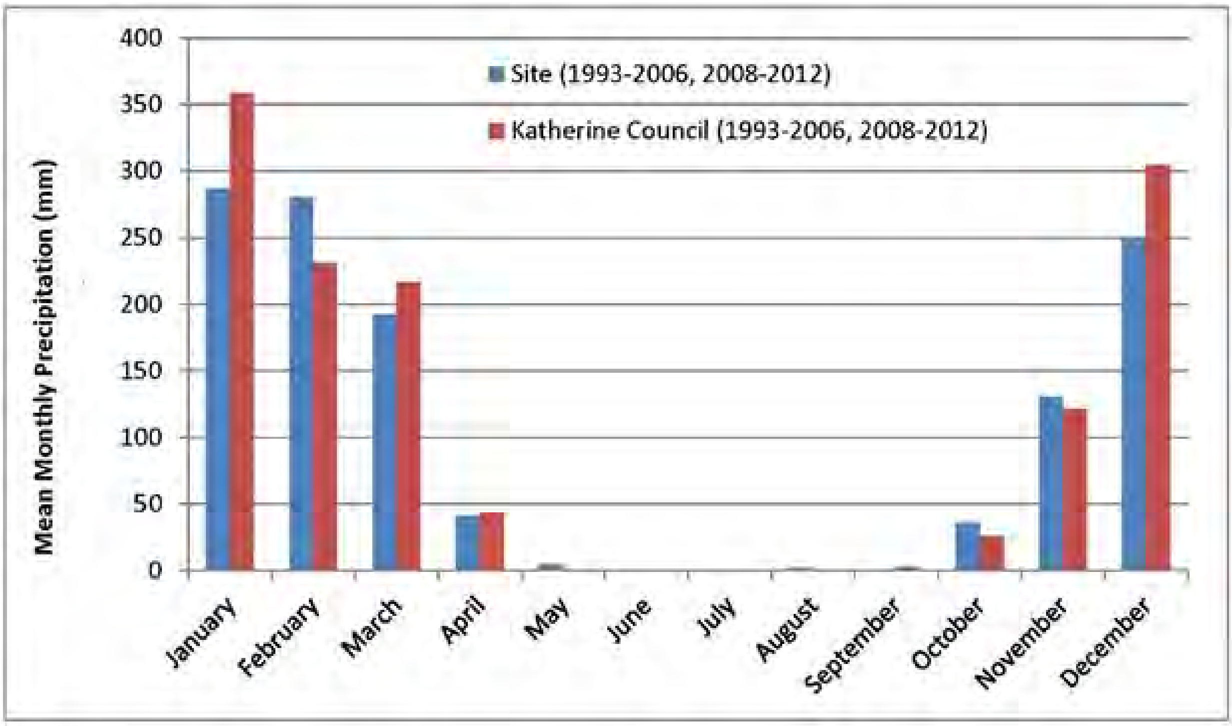


Figure 11-1 Mean Monthly Rainfall at Mount Todd and Katherine (1993 to 2012)

Temperature

Based on data from 1937 to 1985, Katherine has mean maximum temperatures ranging from 29.9°C in June to 38.0°C in November. Minimum temperatures at Katherine range from 13.2°C in July to 24.7°C in November (BOM 2011).

Potential Evapotranspiration

Point source annual average maximum evapotranspiration for the Batman Pit is 2388.17mm (Donohue *et al*. 2009), and pan evaporation is estimated at 2,582mm (Appendix K). Both evaporation values are slightly less than twice the annual rainfall, thus evaporation from a water body, fully exposed to solar radiation, far exceeds the precipitation the area receives.

Net Recharge

Groundwater recharge estimates for the Batman Pit is 13.75mm/year (approximately 1% of precipitation) with a range of 0.7 to 271.5mm/year (0.1% to 26% of precipitation) (GA-CSIRO 2012).

Although the site receives over a metre of precipitation on a yearly basis, anecdotal evidence from field personnel indicates that most precipitation does not infiltrate into the ground. Rather, it runs off (often as sheet flow) into the nearest drainage (Appendix K).

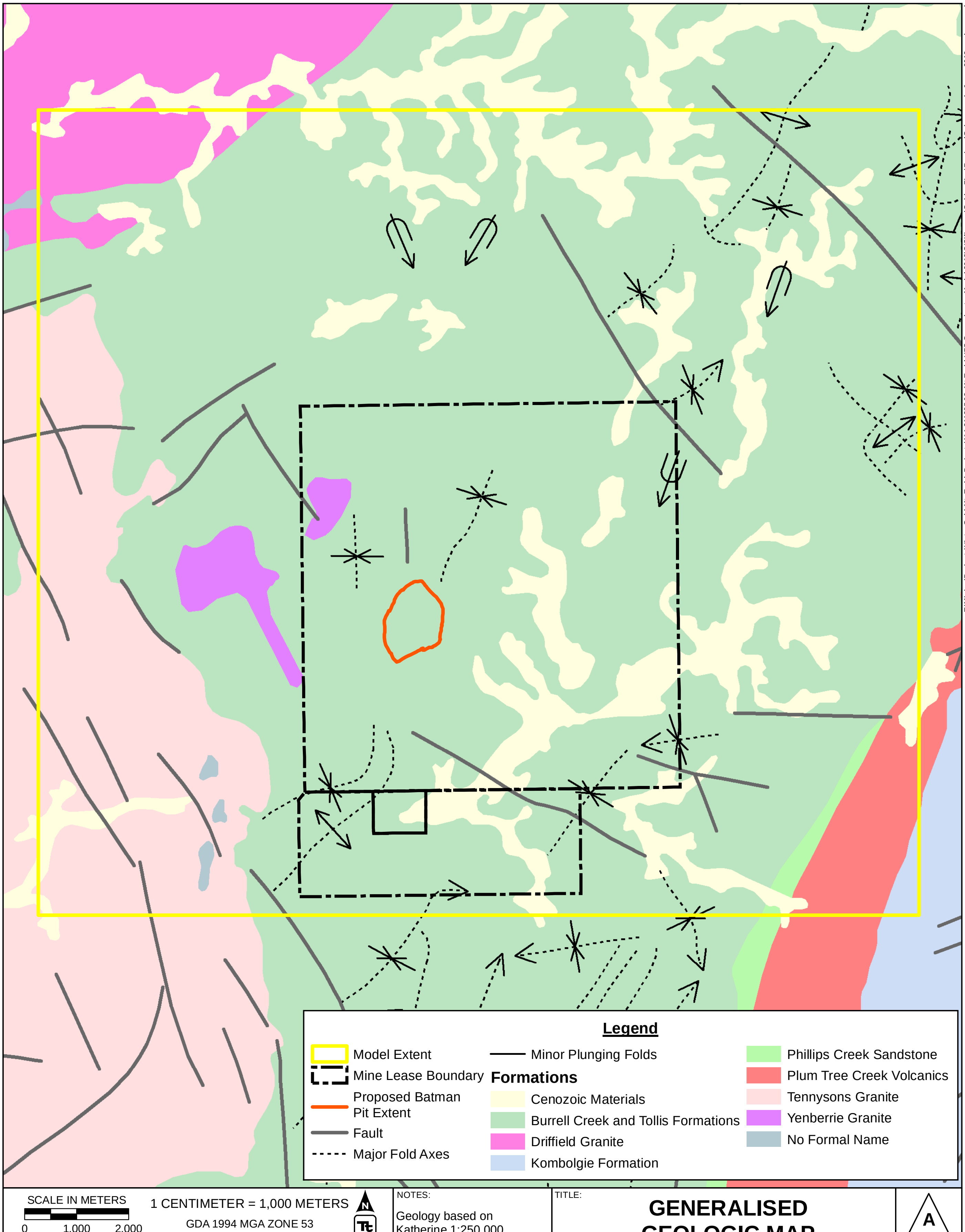
11.3.3 Geological Setting

Information regarding the geological setting at Mt Todd was obtained from the Edith River Region 1:100,000 Geology (Needham *et al*. 1989), Katherine 1:250,000 Geology (Sweet *et al*. 1994) and its explanatory notes (Kruse *et al*. 1994) and Vista Gold geological modelling as a result of exploration and groundwater drilling programs and previous Batman Pit face mapping activities.

The Mt Todd deposit is located in the Early Proterozoic Pine Creek Geosyncline. Figure 11-2 provides a generalised geologic map of the mine area. Brief descriptions of the units encountered near the project area are provided below:

- **alluvial deposits** (Cenozoic) occur as small-scale deposits in creeks and river beds and on low-lying areas adjacent to the Edith River;
- **Kombolgie Formation** (Paleoproterozoic) is a massive sandstone that forms the Arnhem Plateau east of the site and overlies the Edith River Group;
- **Edith River Group** (Paleoproterozoic) includes the Plum Tree Creek Volcanics and the Phillips Creek Sandstone;
- **Cullen Batholith** (Paleoproterozoic) units include the Yenberrie Leucogranite, Driffield Granite, and Tennysons Leucogranite. The Cullen Batholith underlies the entire project area at depth, and its intrusion resulted in the metamorphism of the older Finniss River Group formations and the uplift of the Yinberrie Hills just west of the mine site; and
- **Finniss River Group** (Paleoproterozoic) formations comprise much of the bedrock in the project area and are folded and fractured metasediments with a thick weathered zone at the surface. The Finniss River Group includes the Burrell Creek Formation and the Tollis Formation, both of which contain greywacke, phyllite, slate, and siltstone lithologies. These formations have experienced significant contact metamorphism due to the intrusion of the Cullen Batholith units.

In this report, the Burrell Creek and Tollis Formations are grouped together due to their similarity both geologically and hydrogeologically and are referred to as BCTF.



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NOTES:
Geology based on Katherine 1:250,000 geologic map (Sweet et al., 1994)

TITLE:
GENERALISED GEOLOGIC MAP

REVISION A

PROJECT: MT. TODD GROUNDWATER MODEL

LOCATION: NORTHERN TERRITORY, AUSTRALIA

PROJECT NO.: 114-311285.02

DATE: 05/2013

Figure 11-2

11.3.4 Hydrology Setting

The natural hydrology of the project site is dominated by the perennial Edith River and its tributaries. The Edith River stream gauge has had recorded measurable flow approximately 70% of the time. During dry years the river bed has been observed to go dry, however, even when the surface flow is not measurable, there is subsurface flow through the underlying alluvium. The creeks feeding the Edith River are ephemeral.

Surface Water Flows

Flow data were publicly available from DLRM and the Beurea of Meteorolgy for the Edith River below the mine site, 5km upstream from the Stuart Highway (station G8140152). Surface water flows in the Edith River at this site averaged approximately 6m^3/s since the 1960's, but the average is approximately 8.7m^3/s since the mid-1990's. Flows peaked at approximately 1,150m^3/s after a significant rainfall event in December 2011. Edith River surface water flows were observed to be of similar scale both at the mine and down stream of the mine during the Dry Season. It appears that, at least during the Dry Season, most surface water flow in the Edith River near the mine site originates in the Arnhem Escarpment. Only a minor component would be expected to be from discharge of groundwater associated with the mine site. However, no flow data have been obtained to support this observation.

Available data regarding Edith River flow rates were used in conjunction with precipitation and catchment areas to determine the approximate percentage of precipitation that becomes runoff into the streams. Results indicate that approximately 35% of precipitation enters the Edith River as runoff.

Water Retention Facilities

Another aspect of hydrology in the project area is the presence of anthropogenic water retention facilities, several of which are potentially significant (Figure 1-2):

- **Batman Pit** – the existing Batman Pit (also called RP3) partially filled with water following mine closure in 2000. By late 2004, photographic evidence suggests that water had reached an elevation of approximately 75m AHD. The majority of the water is believed to be due to rainfall within the pit and its catchment area. In addition, since 2005 Batman Pit has been used for temporary storage and treatment of AMD. It receives water from RP1 and several other water retention areas at the mine site as needed.

  Batman Pit is a potential source of groundwater recharge, but the low hydraulic conductivity of the rock limits interaction between groundwater and pit waters. During mining, the pit will be dewatered and deepened and will act as a groundwater sink;

- **RP1** – the WRD water retention pond (RP1) receives runoff from the catchment that drains the WRD. Some of the runoff is AMD from the WRD which during historical mining operations was pumped to TSF1. Currently, excess water from RP1 is pumped to the Batman Pit for treatment prior to discharge. RP1 is not lined and is a source of groundwater recharge; and

- **TSF1** – TSF1 (also called RP7) contains a significant depth of water. During mine operations, it received drainage from the WRD. It was also used from approximately 2000 to 2006 to receive water from the WRD retention pond (RP1), until that water was redirected to the Batman Pit (MWH 2006). In addition, TSF1 receives inflow from rainfall on its surface.

  TSF1 has an underdrain system, however, the underdrain system was deactivated after mining ceased in 2000. Seepage from TSF1 occurs through and / or beneath the south and west embankment. TSF1 allows some water to infiltrate through its base directly into bedrock (Earth Systems 2012).

TSF1 acts as a groundwater recharge source and is expected to do so during the first five years of mine operations, when it will be recommissioned and receivee tailings, and for some time afterward as it drains following the redirection of the tailings to the proposed new TSF2. Ultimately, when the tailings have drained after TSF1 closure, TSF1 is expected to cease being a groundwater recharge source;

- **RWD** – the RWD resulted from damming of a tributary of Horseshoe Creek northeast of TSF1. It is used to supply water requirements and acts as a source of groundwater recharge; and
- **Golf and Tollis Pits** – former mining activities resulted in the Golf and Tollis Pits which both contain small pit lakes. These pits are located north of Batman Pit and directly west of TSF1. Water levels are within 5m of ground surface and appear to decant after high rainfall. These historic mine pits may act as a minor source of groundwater recharge.

Other ponds at the site are lined and/or small and are not expected to have a significant effect on local hydrogeology. The new TSF2 will be lined and is not expected to contribute to groundwater as a recharge or discharge point. It will, however, eliminate natural recharge in the area.

Influence of Surface Water Impoundments

Based on the groundwater elevation data TSF1, RP1, and the RWD all appear to function as flow-through features. Groundwater elevations are higher on one side of the impoundment than the other, and surface water elevations within the impoundment fall between the upgradient and downgradient elevations. All three of these surface water impoundments interact with groundwater. Seepage evaluations of these impoundments are in progress but is not yet complete.

Groundwater elevations around TSF1, RP1 and the RWD are higher than pre-mining levels due to recharge from the surface water impoundments. Artesian conditions have been observed in bores:

- 3A, BW6, TDMB4S and TDMB4D – downgradient of TSF1; and
- MB6S, MB6D, MB7S, and MB7D – downgradient of RP1.

Some artesian bores appear to be perennial. Constant flow, even at low rates, can result in the discharge of large volumes of groundwater. For example, an order of magnitude estimate of discharge in bores MB6 and MB7 (in July / August 2011) was 10L/minute, equivalent to 5ML/year of discharge out of RP1 (GHD 2012).

Influence of Batman Pit

Active water management (including pumping into the Batman Pit) has occurred since at least 2005. Anecdotal information indicates that groundwater inflow was a relatively minor component of the pit water, both during and after mine operation. However, no actual water levels were measured between mine closure in 2000 and the time when Vista Gold commenced measuring water levels. A number of photographs have been obtained (DME 2013) that allow estimation of approximate water levels in the pit. Combined with the site survey information, these photographs provide snapshots of water levels in the pit at various times (Table 11-1). Prior to approximately 2005, the pit water levels represent primarily rainfall, with a minor contribution from groundwater inflow. After 2005, Batman Pit was also used for storage of water from other impoundments at the mine.

Table 11-1 Water Levels from Anecdotal Observations and Survey

Information or image source	Date	Estimated pit lake elevation (m AHD)	Notes
Date of mine closure	July 2000	40	Bottom of pit
Photograph (www.nt.gov.au/d/mttodd)	April 2003	70	Estimated to within +/- 2m
	October 2004	75	
	May 2006	95	Pumping into pit had begun. Elevation estimated to within +/- 1m
	June 2007	110	Continued pumping
Vista Gold data	November 2009	130	Water level maintenance
	September 2010	130	
	September 2011	133	

Batman Pit is poorly connected to groundwater, based on a comparison of water surface elevations in the pit to groundwater elevations measured in nearby bores. Between November 2010 and December 2011, water levels in Batman Pit were consistently between 130m and 134m AHD. By contrast, groundwater elevations in BPMB01, BPMB02 and BW5 were between 135 and 151m AHD, once the water levels equilibrated after well installation. Thus, Batman Pit appears to have had consistently lower water levels than the nearby bores, despite the pit having received water pumped to it.

The lower water levels in Batman Pit are due to a combination of evaporation, very low rates of groundwater inflow from surrounding bedrock and management of the Batman Pit water levels by Vista Gold staff. If Batman Pit was well-connected to the groundwater system via high-conductivity fracture systems and had lower water levels than the surrounding area, it would be expected to serve as a groundwater sink, and the water levels measured in the surrounding bores would be expected to decrease in response to the low levels in Batman Pit. If water were to be continuously pumped into Batman Pit to raise its water level above the surrounding groundwater elevation, then some minor water seepage out of the pit through fractures in the pit walls would be expected to occur; however, this situation has not been observed.

Influence of Edith River and Tributaries

During the Wet Season, high flows occur in the both the ephemeral creeks and the Edith River. To clarify the behaviour of the Edith River and its tributaries at the mine site, specific observations approximately the creeks and streams were made during several site visits (GHD 2012).

Observations in May 2011, suggested that high flows during the Wet Season had occurred in the ephemeral creeks and that the Edith River was subject to flood far above its banks. The ephemeral Stow Creek, the diversion drain to the east of TSF1 and Horseshoe Creek still had observable surface flows along their reaches. Batman Creek and the ephemeral creeks north of the mine area had ceased flowing in May, although large refuge pools remained.

In July / August 2011, surface water pools remained in Batman Creek and the ephemeral creeks north of the mine area. Surface water flow had ceased in Stow Creek. Minor surface water flow continued in the Dry Season (July / August) along the eastern diversion drain and Horseshoe Creek. Horseshoe Creek pools were full and groundwater elevations in adjacent bores were near-surface. Significant groundwater seeps were observable down-gradient of the southern and eastern walls of the tailings dams and these appeared to be providing the flow in Horseshoe Creek.

In all site visits during 2011, groundwater elevations in bores adjacent to natural drainage lines were consistently similar to the water level elevations observed in the surface water pools. This suggests a high degree of connectivity and potential interaction between surface water and groundwater.

11.3.5 Hydrogeological Setting

Background Hydrogeology

The hydrogeological setting was established through fieldwork (groundwater monitoring and borehole drilling) in conjunction with the existing literature, primarily Rockwater (1988, 1989 and 1994), Power and Water Authority (1989 and 1989a), MWH (2006), online resources NRETAS (2011e) and ongoing monitoring by Vista Gold.

The hydrogeology of the Pine Creek mining region, described by Power and Water Authority (1989a), highlights the Burrell Creek Formation as capable of providing sustainable yields of 0.5 to 2L/s in zones of intense alteration, faulting or shearing.

Groundwater Flow

Groundwater flow direction of north to south towards the Edith River remain constant throughout the year. Groundwater discharge to the Edith River and its tributaries is expected, since groundwater elevations are higher than the adjacent creek and river bed elevations. The expected regional groundwater flow direction from the Arnhem Escarpment in the east to the Daly River in the west was not observed at the mine site. However, a regional east to west flow direction is believed to be present based on the topography and the fact that the Edith River (which appears to act as a groundwater discharge point) flows from east to west.

Protected Beneficial Uses

Groundwater in the region has a declared beneficial use for raw water for drinking water, raw water for agriculture, and raw water for industrial purposes (NRETAS 2011c) and is referred to as the Katherine Area Groundwater. Surface water in the Edith River across and downstream of the site has a declared beneficial use for aquatic ecosystem protection (NRETAS 2011d).

Groundwater Resource Utilisation

An online bore search indicated the presence of four operating groundwater production bores within approximately 10km of the project site, not counting the bores installed for camp and mining water supply at the project site in the past (Table 11-2). One bore at the mine site, BW6P (RN026131), is currently used for groundwater production.

Table 11-2 Operating Monitored Bores on Neighbouring Properties

Bore name	Bore report number	Depth to water (m)	Date of water level	Bore depth (m)	Screen depth (m from and to)	Monitored
Edith Falls	RN024418	5.7	19/07/1986	45	33 to 45	yes
Werenbun Outstation 1/93	RN028738	11.6	2/09/1993	55.5	50 to 52	yes
Edith Falls	RN032153	9.6	12/07/1999	50	37 to 43.5	yes
Jawoyn Aboriginal Land Trust	RN036978	5	9/03/2010	49	41 to 43	yes

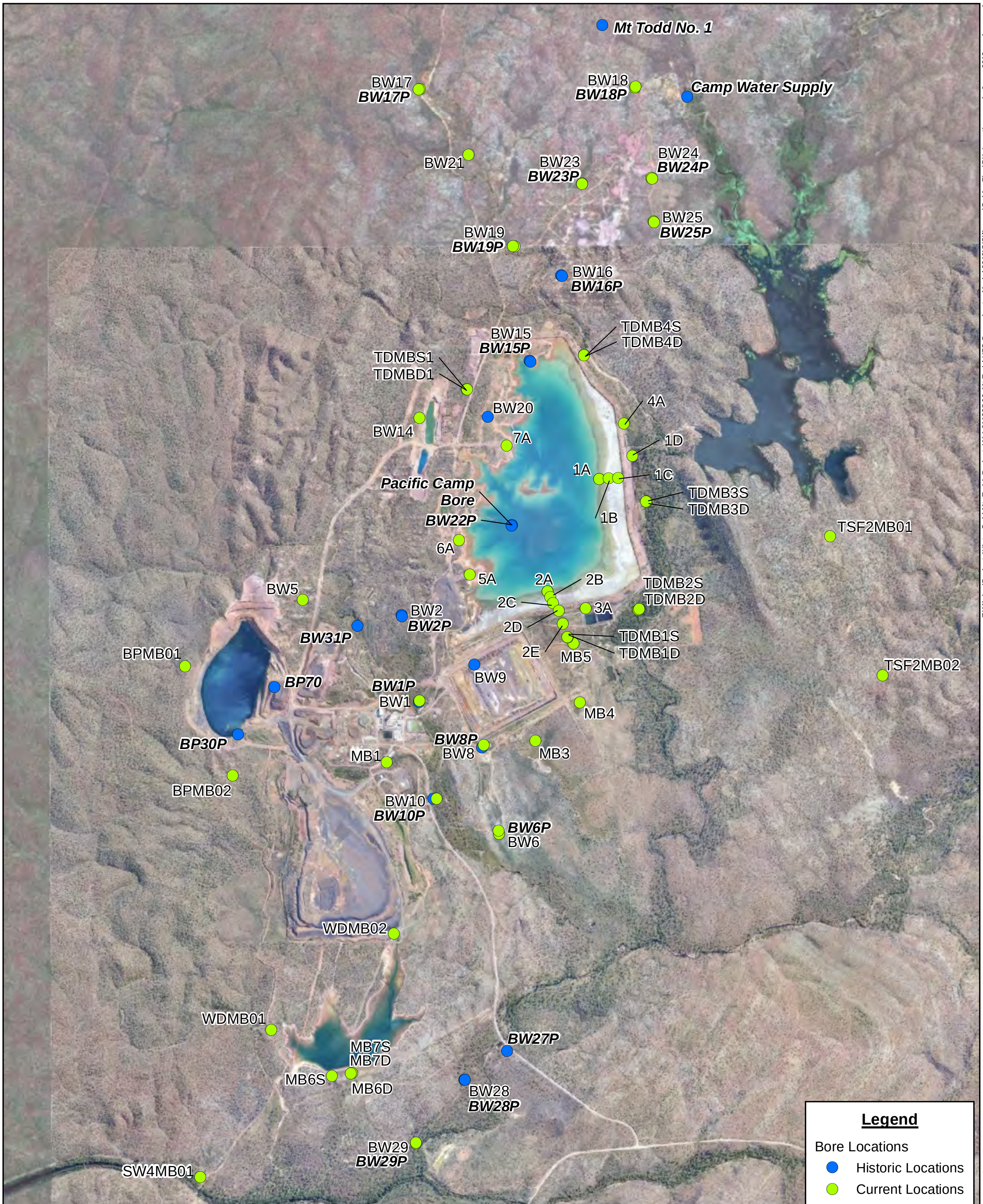
Groundwater Monitoring Infrastructure – Pre-existing Bores

Extensive groundwater pumping and monitoring infrastructure is present in the project area. Bores were installed during a number of field assessments over the course of many years and include (Figure 11-3):

- Camp bore BP70, Mt Todd No. 1, Camp Water Supply, and Pacific Camp Bore (locations approximate);
- BW1 to BW31P (Rockwater 1988, 1989 and 1994). This installation effort focussed on obtaining adequate water resources for mine development. The bores were installed in the BCTF and encountered primarily greywacke, hornfelsed greywacke, siltstone and shale. The bores were airlifted, and many were subjected to pumping tests;
- TDMB#1 to TDMB#6 (Knight Pièsold 1996), each consisting of a shallow and deep bore. Five of the pairs were located by Earth Systems (2012) and GHD (2012), renamed TDMBD1, TDMBS1, and TDMB1S & D to TDMB4S & D, and re-surveyed. Construction logs were provided, but no lithologic logs were available for these bores;
- MB1 to MB7. No information could be located for these bores;
- WD1 to WD2. No information could be located for these bores. They are reportedly submerged under RP1 (GHD 2012);
- Piezometers 1A through 1D, 2A through 2E, 3A, 4A, 5A, 6A, and 7A (Earth Systems 2012). These were installed and subjected to hydraulic testing as part of a detailed assessment of TSF1.
- SW4MB01, TSF2MB01, TSF2MB02, BPMB01, BPMB02, WDMB01 and WDMB02 (GHD 2012).

In addition to measuring water levels in the monitoring bores, regular monitoring of water chemistry in several of the surface water bodies and impoundments has been performed. In some cases, these measurements can be used to provide insight into the groundwater elevation and quality.

Where monitoring bore logs were lacking sufficient detail, field crews (GHD 2012) used a downhole camera to investigate the bore. These surveys revealed that there was considerable variability in bore construction approaches. Earth Systems (2012), GHD (2012) and Knight Pièsold (1996) typically utilised machine-slotted screens, filter pack and bentonite or cement seals. The other bores were typically constructed using coarse grinder-ground vertical slots and no filter pack. The collar seals were also missing in some cases, such as the MB series and some BW bores.



SCALE IN METRES

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1 CENTIMETRE = 375 METRES

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NOTES:
Bores originally installed for water supply or dewatering purposes are shown in bold italics.

This figure contains imagery from ESRI imagery web mapping service, provider of worldwide basemap, aerial, and satellite imagery. Go to www.esri.com for further information.

TITLE:

BORE LOCATION MAP

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PROJECT: MT. TODD GROUNDWATER MODEL

LOCATION: NORTHERN TERRITORY, AUSTRALIA

PROJECT NO.: 114-311285.02

DATE: 05/2013

Figure 11-3

Groundwater Monitoring Infrastructure – New Bore Infrastructure

A number of new monitoring bores were installed by GHD (2012) as part of the most recent field investigation. The new bores were installed for the following groundwater elevation monitoring purposes:

- BPMB01 and BPMB02 – monitoring of the current and proposed Batman Pit highwall water levels and interaction with the proposed WRD;
- WDMB01 and WDMB02 – monitoring of the RP1 and WRD area;
- TSF2MB01 and TSF2MB02 – monitoring of the interactions between the proposed TSF2 location and the nearby surface water features (RWD and Stow Creek); and
- SW4MB01 – monitoring groundwater adjacent to the Edith River.

Available borehole logs and aquifer test data are presented in Appendix K.

The new bores were installed in locations outside the footprints of nearby existing and proposed infrastructure. Of the bores shown on Figure 11-3, BPMB01, BPMB02, TSF2MB01, TSF2MB02, SW4MB01, BW29, BW17, BW18, and BW6 can be considered boundary bores. As the proposed Project develops, additional monitoring bores may be necessary.

Groundwater Level Monitoring Results

Groundwater elevation data have been plotted for one Dry Season monitoring event and one Wet Season monitoring event. Figure 11-4 provides a potentiometric surface map for the November to December 2010 monitoring event, which is at the end of the Dry Season (low water levels). Figure 11-5 provides a potentiometric surface map for the May 2011 monitoring event, illustrating a marked seasonal variation associated with Wet Season recharge (high water levels).

When generating the potentiometric surface maps, all water levels were assumed to represent the uppermost saturated unit. This assumption is supported by the observation that when pairs of shallow and deep monitoring bores were present, the measured groundwater elevations in each of the two bores were similar.

Ground level contours and recent data sets are presented in Appendix K.

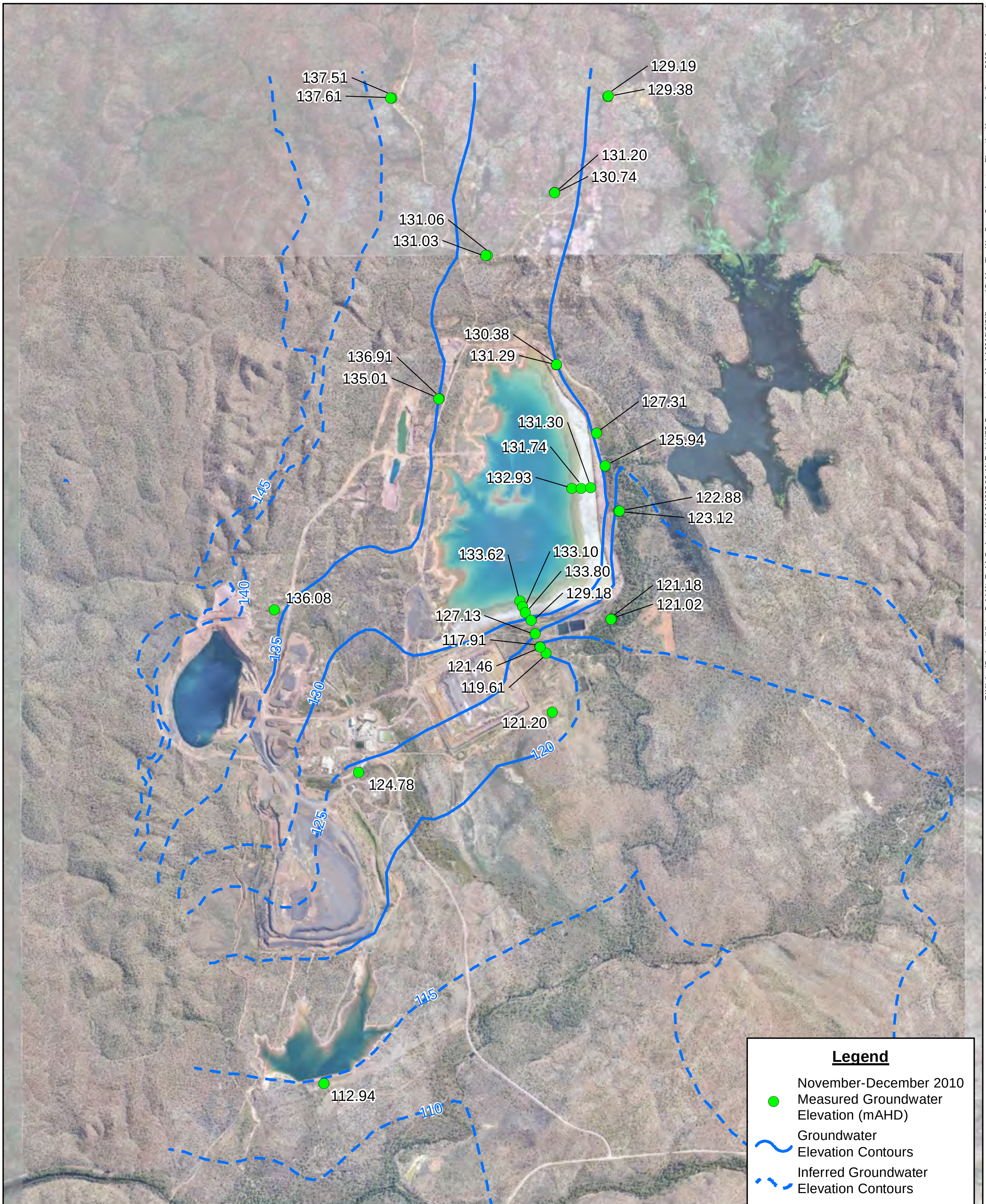
11.3.6 Aquifer Properties

Aquifer properties were ascertained from airlift yield tests and aquifer testing.

Airlift Yields

Airlift yield tests are routinely performed when drilling water bores for investigation and supply purposes. Airlift yields were available for all the BW series bores and for the most recent bores (GHD 2012). These data are presented graphically in Figure 11-6 as a frequency histogram. All airlift values were from the Burrell Creek and Tollis Formations.

In the vicinity of Batman Pit, BCTF has been metamorphosed (hornfelsed). The tested bores nearest to Batman Pit are BW3, BW4, BW5, BW13, BW30P, BPMB01 and BPMB02. Of these bores, all but BW30P had airlift yields below 1L/s, and three were dry during drilling. The anomalously low yields support the concept that the hornfelsed BCTF has very low hydraulic conductivity.



SCALE IN METRES

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1 CENTIMETRE = 375 METRES

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GROUNDWATER ELEVATION, NOVEMBER-DECEMBER 2010

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LOCATION: NORTHERN TERRITORY, AUSTRALIA

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Figure 11-4

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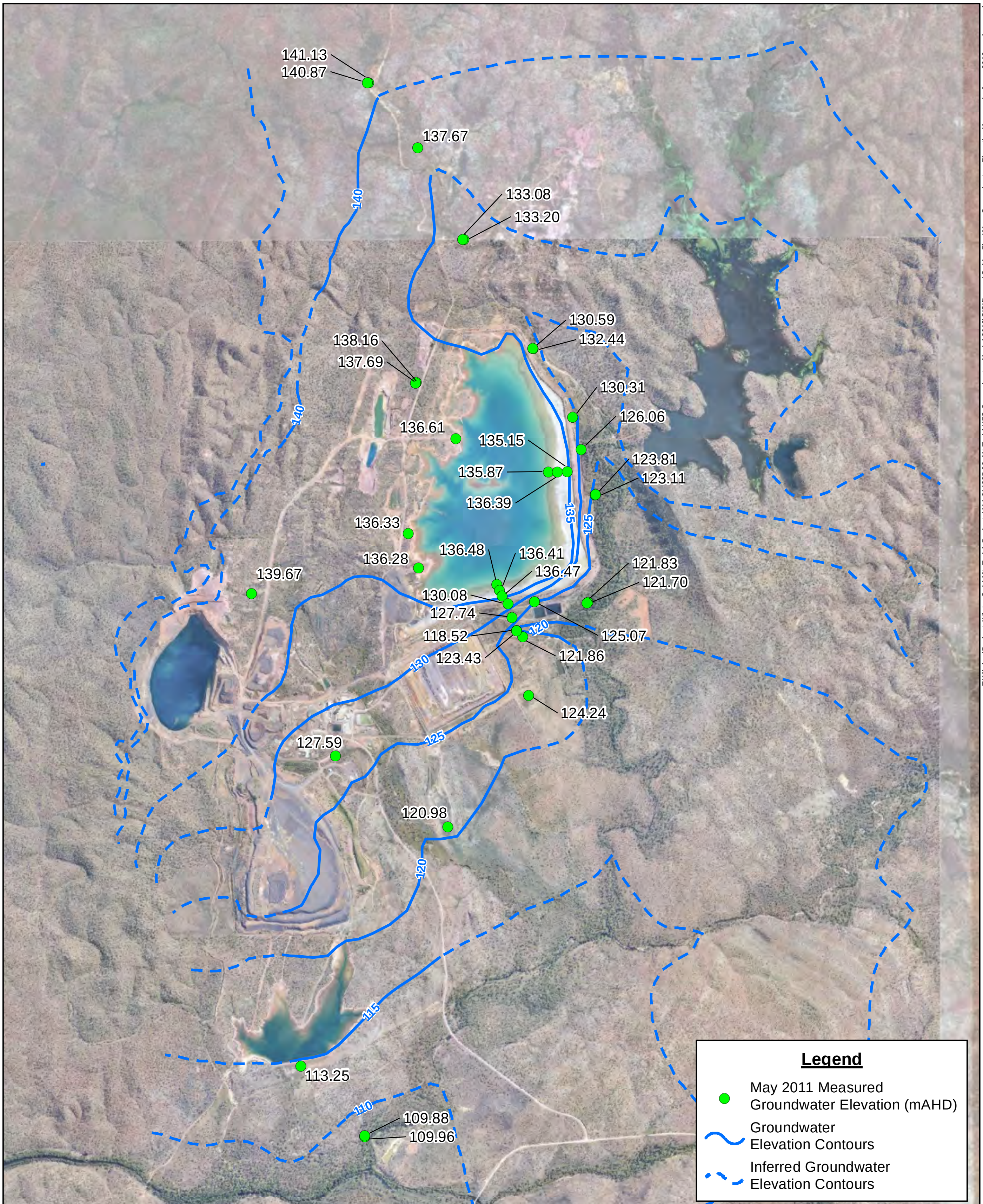

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SCALE IN METRES

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GDA 1994 MGA ZONE 53

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GROUNDWATER ELEVATION, MAY 2011

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LOCATION: NORTHERN TERRITORY, AUSTRALIA

PROJECT NO.: 114-311285.02

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Figure 11-5

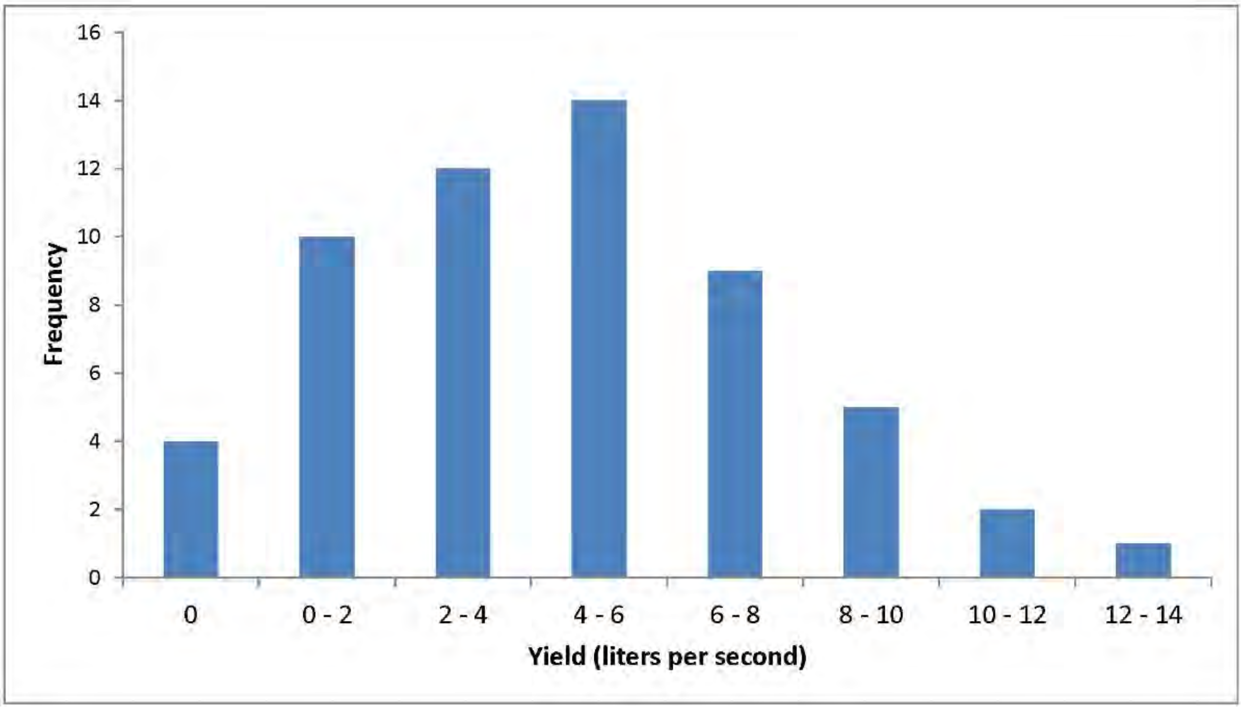


Figure 11-6 Airlift Yield Summary

Pumping Tests and Slug Tests

Pumping and slug tests have been performed over the last 25 years to determine aquifer properties including:

- eleven pumping tests from the Mt Todd site (Rockwater 1988 and 1989) in the BCTF;
- two publically available pumping tests on registered bores within the region (DLRM 2013) which tested the Plum Tree Creek Volcanics at Edith Falls and the BCTF at Werenbun;
- eighteen pumping tests during the most recent field assessments in the BCTF (GHD 2012); and
- two slug injection tests (Golder Associates 2011).

Pumping tests undertaken as part of this study were incorporated into the geochemical sampling program. Pumping tests were undertaken for 30 minutes or to a point at which water levels approached the depth of the pump. Post-pumping, water level recovery was monitored to the static (pre-pumping) level or for up to 30 minutes. Flow rates and water levels were monitored manually and with loggers.

Where pumping tests involved a pumping bore and an observation bore, storage co-efficient values can be interpreted. Data from eight successful pumping tests were interpreted to obtain rock mass transmissivity values for local materials. Outputs from all pumping tests are provided in Appendix K.

Slug tests were performed where the rock mass permeability was too low for sustained pumping tests. Four slug tests were conducted at four bores in altered BCTF in the Batman Pit area (Golder Associates 2011 and GHD 2012).

11.3.7 Groundwater Velocities

Groundwater flow velocities using the Darcy velocity equation for the current groundwater conditions were calculated based on the transmissivity values collected above, assumed effective porosity values based on literature, groundwater elevations and distances (Table 11-3).

Table 11-3 Example Darcy Velocities

Point 1	Point 2	Hydraulic conductivity (m/day)	Effective Porosity	Water Table Elevation (m AHD)		Distance (m)	Hydraulic Gradient	Velocity (m/day)
				Point 1	Point 2			
BW5	MB1	0.19	0.01	132.94	125.35	1525	0.0050	0.14
BPMB02	WDMB02	0.0029	0.01	136.98	132.94	1675	0.0024	0.0027
MB1	BW6	1.4	0.01	125.35	120.03	920	0.0058	0.76
BW17P	BW19P	0.2	0.01	141.00	133.14	1310	0.0060	0.11

11.3.8 Groundwater Chemistry

Water sampling provided baseline geochemistry values for groundwaters in the region and adjacent to mine features. Water analyses assisted in supporting conceptual hydrogeological models by confirming groundwater flow directions and providing support for hypotheses Details on groundwater chemistry sampling and analysis are provided in Appendix K.

Chemistry Analyses

Groundwater chemistry analyses were undertaken to assist in the development of conceptual hydrogeological models and identifying groundwater flow paths, rather than a true contamination assessment of the groundwater system at Mt Todd. The groundwater analyses provide context as background or baseline groundwater concentrations for the proposed development. Results prevent wrongly attributing later-identified contamination that may be present due to historical activities or natural mineralisation to the proposed operations.

Groundwater chemistry results are provided in Appendix K. Groundwaters are compared to ANZECC & ARMCANZ (2000) guidelines for freshwater aquatic ecosystems at the 95% species protection level (FAE95%), guidelines for long term irrigation values, guidelines for livestock watering and Australian Drinking Water Guidelines (NHMRC & NRMMC 2004). Groundwater at Mt Todd is not intended for such uses and these guidelines are used to provide a reference point only. Groundwaters do discharge into surface waters used for such purposes.

Chemistry Discussion

The presence of elevated levels of contaminants and major ions in bores down-gradient from water retaining structures supports the conceptual models developed for the site. Elevated levels of contaminants were observed in most bores, even those designed to be background or boundary bores. Existing elevated contaminants across the site included:

- metals and metalloids: arsenic, cobalt, lead, iron, manganese, zinc, copper, aluminium, chromium, and molybdenum; and
- inorganics: chloride, cyanide (total), and sulfate.

Background water in the Mt Todd area may have elevated contaminants due to:

- natural background levels associated with the area containing significant natural mineralisation;
- historical prospecting and small scale workings distributed over the area, disturbing sulfide mineralisation; and
- features associated to the existing Mt Todd mine site.

Waters contaminated with AMD and process water are present in the surface water retaining features at Mt Todd including:

- TSF1;
- HLP;
- LGO stockpile;
- process plant;
- open cut pit;
- WRD; and
- WRD RP1.

These features present potential sources of groundwater contamination through AMD.

The fact that 'background' or 'boundary' bores exceed the Australian drinking water guidelines (NHMRC & NRMMC 2004) demonstrates that the existing groundwater at Mt Todd is not suitable as a reliable source of potable water without treatment.

11.3.9 Groundwater Demand

Groundwater will be extracted as part of the proposed pit dewatering using sumps. Groundwater removed from the pit is likely to be acidic and contain elevated concentrations of metals and will be unfit for use as a raw or potable supply without additional treatment.

This study assumes that all potable and raw water will be sourced from surface water bodies (i.e. the RWD). Existing pumping bores (including BW6P which is being used for raw water) are too elevated in contaminant concentrations for use as potable or raw water without treatment.

11.4 Groundwater Modelling

11.4.1 Introduction

The model simulated the groundwater conditions existing prior to Vista Gold's acquisition of the site, the mining activities proposed by Vista Gold, and the groundwater conditions following closure of the mining operations. The primary objectives of the groundwater flow modelling were to:

- provide estimates of the amount of groundwater inflow to the enlarged and deepened Batman Pit during mining and thereby facilitate optimal design of groundwater dewatering systems for the mine;
- predict the effects of mine dewatering and mine water management operations on groundwater levels and surface water flows;
- predict post-mining pit lake formation and pit-lake water balance; and
- estimate post-mining changes in groundwater levels and surface water flows.

11.4.2 Conceptual Groundwater Flow Model

The conceptual model of groundwater flow is a fractured rock aquifer with a thick weathered zone. In general, flow in the aquifer is away from recharge areas and toward groundwater discharge areas. For the most part, streams in the area act as the discharge points, and topographic highs and anthropogenic surface water impoundments act as recharge areas. Thus, groundwater flow is generally toward the local streams and drainages where groundwater can discharge into the drainage, and the potentiometric surface generally follows topography. Thus, water originating in the vicinity of the mine and its infrastructure would be expected to migrate offsite, likely as discharge into surface water.

The path groundwater follows through the project area is influenced by the regional groundwater gradient and the hydraulic conductivity of the materials in the area. The local flow direction is influenced by differences in recharge, local topography, and local hydraulic conductivity. In addition, any project-related pumping will influence the local flow direction.

The regional groundwater gradient in the project area is toward the southwest. The groundwater flow direction generally follows topography. Regionally, topography slopes away from the Arnhem Plateau in the Nitmiluk National Park. The Edith River has its source in the Arnhem Plateau and flows generally west-southwest toward the Ferguson River. Regional groundwater flow follows the same trend, generally moving toward the west-southwest. Local features such as surface water impoundments are not expected to have a regional effect.

The primary fractured rock unit through which groundwater flow occurs in the project area is the BCTF. Where the BCTF has been contact-metamorphosed by the local intrusions of the Cullen Batholith units, it is relatively impermeable. The Batman Pit is located in metamorphosed (hornfelsed) BCTF, hence, there is expected to be very little groundwater recharge or discharge through the walls of the pit. East of Batman Pit, the BCTF becomes less metamorphosed and has a higher hydraulic conductivity. The approximate location, geometry and extent of the transition zone can be estimated from drilling and hydraulic testing performed over the last 25 years of investigation in the project area. Some of the surface water impoundments, such as TSF1 and the RWD, are located in the less-metamorphosed area of the BCTF and act as recharge features. In addition, AMD from TSF1 appears to be seeping through and under the embankment to discharge at the surface.

The weathering profile is hydrogeologically significant in the project area. Based on examination of numerous boring logs, the top 3m of material is generally completely weathered, very highly fractured, or unconsolidated. Alluvium often extends somewhat deeper than 3m below streambeds. Weathering of the bedrock is generally observed down to approximately 25 to 30m below land surface (bls). In borehole logs, weathering is often associated with increased fracturing, infilling of fractures with clay or mineralisation, or oxidation. The degree of weathering decreases with depth.

The alluvium and uppermost weathered portion of bedrock have the potential to transmit significant water, especially during rain events. However, they are generally unsaturated except in the immediate vicinity of the local streams and surface water bodies. Also, the infilling and mineralisation along fractures in the weathered zone above 30m depth has the potential to cause a decrease in their transmissivity. Historically the primary flow zone was observed by prior hydrogeologists to be approximately 30 to 70m below the land surface in the BCTF (Rockwater 1988 and 1989).

11.4.3 Groundwater Model Scale

The groundwater model domain consisted of a rectangular area extending approximately 15.4km north to south and approximately 16.9km east to west, with the project area approximately centered within the domain. The model cell horizontal dimensions were 50m by 50m in the area encompassing the existing

Batman Pit and the proposed enlargement of the pit. The horizontal cell dimensions gradually increase outside that area to a maximum of 500m by 500m at the corners of the domain.

Simulation of a regional area limits the resolution of the model grid, which in turn limits the resolution and accuracy of the model simulations. Hydrogeologic features smaller than the grid resolution are typically not simulated, and geometries and distributions are approximate. Small-magnitude flows, small water-level changes, and steep hydraulic gradients are therefore difficult for a regional model to replicate.

The regional-scale groundwater modelling was not intended to model site features such as the RWD, TSF1, the WRD, and the WRD retention pond (RP1) on a scale that would accurately predict seepage rates from the facilities and the associated impacts. Although those features were included in the regional groundwater flow model, their impacts were simulated in a more generalised fashion. Other separate studies, such as seepage modelling, have been or are being conducted to assess the seepage rates and impacts associated with those facilities.

The overall modelling approach was to construct groundwater flow models to simulate steady-state pre-mining conditions, transient mine development and dewatering, and transient post-mining conditions.

1) The steady-state pre-mining conditions were based on historical water level, stream-flow and hydraulic property data. The flow model was first calibrated to the steady-state water level data, forming the basis for the subsequent transient flow models.

2) The steady-state calibrated model was then converted to a transient model and further calibrated to water-level changes observed at the monitoring bores during the aquifer testing. The calibrated transient model was used as the basis for mining and post-mining phase models.

3) The mining-phase transient model simulated the step-wise mining and dewatering of the Batman Pit during the operational period.

4) The post-mining phase simulated pit lake development from the refilling of the pit with groundwater, precipitation and runoff following the end of dewatering.

11.4.4 Groundwater Model Conceptualisation

The groundwater flow model was implemented using the MODFLOW-SURFACT finite-difference code (Version 4; HydroGeoLogic 2011). The graphical user interface Groundwater Vistas (Version 6.29, Build 1; Environmental Simulations, Inc., 2011) was used in model construction.

Vertical discretisation of the model grid was based on the hydrogeological characteristics of the area and the proposed mine plan.

1) The top of the uppermost layer represented the land surface. The uppermost layer itself was 3m thick and represented the highly-weathered, higher-permeability regolith and alluvial fill along ephemeral drainages and the Edith River.

2) The second layer was 24m thick and was designed to allow representation of the upper weathered portion of the bedrock.

3) The thicknesses of model layers 3 and 4 were variable to accommodate the topographic difference between the land surface and the horizontal bottom of layer 4 at a constant elevation of 32m AHD. The model layers below layer 4 were horizontal, and each was of a constant thickness.

4) Layers 5 through 11 were each 48m thick, twice the design height of the proposed Batman Pit benches, to facilitate simulation of the mining progression.

5) Layers 12 through 15 increased progressively in thickness, such that the bottom of the model was at an elevation of -2000m AHD.

Model Hydraulic Conductivity (K) Distribution

The Cenozoic surficial sediments and highly weathered regolith at ground surface have the highest horizontal hydraulic conductivity of the modelled geologic units, ranging up to 5m/d.

The granite and hornfelsed BCTF have the lowest horizontal hydraulic conductivity, in the range of $1x10^{-5}$m/d. These two units form effective barriers to groundwater flow.

The less-metamorphosed BCTF has significantly higher hydraulic conductivity, in the range of $1x10^{-1}$m/d. The degree of fracturing varies with location and with depth. Thus, the hydraulic conductivity would also be expected to fluctuate between locations.

The weathered granite has significantly higher hydraulic conductivity than fresh granite due to the addition of secondary porosity. The weathered BCTF has been observed to have significant infilling of fractures by clay and iron oxide materials, which actually results in a lowering of hydraulic conductivity.

The model was used to calibrate the hydraulic conductivity values for each zone. Table 11-4 shows the calibrated hydraulic conductivities for each modelled hydraulic conductivity (K) zone. Appendix K provides plots of the spatial distribution of hydraulic conductivity zones for each model layer.

Predictive Simulation – Mining Phase

Dewatering of the Batman Pit over the mining phase was simulated using the MODFLOW drain boundary condition. Drain boundaries are useful for simulating the effects of mine dewatering because they remove water from the groundwater system only when head in the drain cell is greater than the elevation of the head specified for the drain cell. The deepening and lateral expansion of the pit was simulated by expanding drain locations within the model grid and lowering the drain elevations over time.

Tailings will be deposited in the existing TSF1 during the initial five years of mining. During that period, the height of the tailings dam would be raised step-wise, and the elevation of the water ponded on the tailings would rise gradually, increasing the head within TSF1. This was simulated by incrementally raising the head assigned to the general head boundary cells representing TSF1 from 136m AHD at the start of the mining phase to 157m AHD by the fifth year. The cessation of use of TSF1 was simulated by turning off the general head boundary cells (flows into TSF1 cease).

The head in the RWD was increased by 2m to 136m AHD at the start of the mining period and maintained at that elevation for the remainder of the simulation period.

Predictive Simulation – Post-mining Phase

Predictive simulation of post-mining conditions was completed using the lake package, based on the final pit shell. In this case, the pit will begin to fill with water derived from the inflow of groundwater, precipitation and runoff. The water level will rise until the decreasing hydraulic gradient in to the pit decreases groundwater inflows and the increasing area of the lake in the pit allows evaporation to balance inflows.

Table 11-4 Calibrated Hydraulic Conductivity

Model Zone	Hydraulic Conductivity (K)	Horizontal Hydraulic Conductivity (m/day)	Vertical Hydraulic Conductivity (m/day)	Description
Unconsolidated	1	5	0.5	Alluvial material in streambeds
	2	2	0.2	Completely weathered bedrock
Weathered Granite	9	0.001	0.001	Weathered Cullen Batholith material
Granite	10	0.00001	0.00001	Cullen Batholith members (Yenberrie Leucogranite, Driffield Granite and Tennysons Leucogranite)
Weathered Volcanics	11	0.001	0.001	Weathered Plum Tree Creek Volcanics
Volcanics	12	0.0001	0.0001	Plum Tree Creek Volcanics
Weathered Burrell Creek and Tollis Formation (BCTF)	3	0.0606	0.0606	Weathered BCTF up to approximately 27m below land surface
BCTF - North	6	0.13	0.13	BCTF in the northern portion of the model
BCTF - Central	7	0.25	0.25	BCTF in the central model area, primarily under and near TSF1
BCTF - South	8	0.17	0.17	BCTF in the southern portion of the model
BCTF - Altered	4	0.00001	0.00001	Hornfelsed BCTF
BCTF - Transition	5	0.019	0.019	Transition between hornfelsed BCTF and less metamorphosed BCTF
Sandstone	14	0.1	0.01	Phillips Creek Sandstone

11.4.5 Potential Impacts

Potential impacts were identified through comparison of the results of the predictive groundwater flow modelling to the conditions simulated by the steady-state results of the calibrated groundwater flow modelling. The background conditions for purposes of identification of potential impacts were assumed to be those at the start of Vista Gold's tenure, as simulated by the steady-state calibrated model.

Predicted Batman Pit Dewatering – Mining Phase

Potential impacts related to the proposed mining-phase activities include changes in groundwater levels, groundwater flow directions, and stream flows as a result of pit dewatering and on-site water management.

Estimated groundwater inflows to the Batman Pit during mining are shown in Figure 11-7. Predicted groundwater inflows ranged from a few litres per second at the start of mining to approximately 30L/s during the final months of mining.

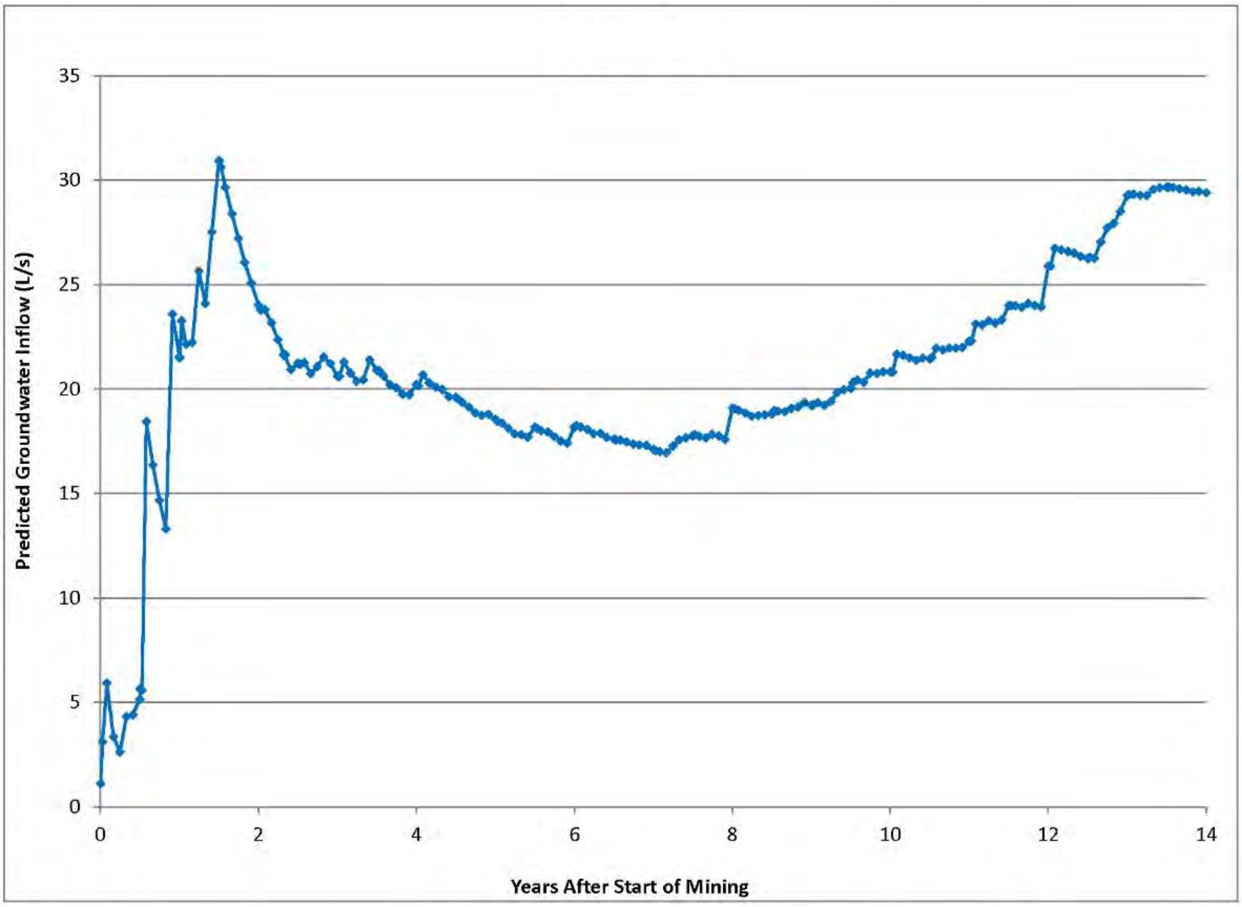


Figure 11-7 Predicted Groundwater Inflows to Batman Pit During Mining

Predicted Batman Pit Lake Water Balance – Post-mining Phase

The post-mining groundwater flow model predicted that a pit lake will form in the Batman Pit after mine dewatering ceases. The predicted water balance for the pit lake through the 500-year simulation period is shown in Figure 11-8. The step-wise changes in the graphed parameters result from the step-wise change in the pit lake surface area from one model layer to the next.

The simulated pit lake water level rose relatively rapidly following cessation of pit dewatering and after 345 years had reached approximate steady-state, at an elevation of approximately 15m AHD and with the water surface covering an area of approximately 66ha.

The model predicted that the post-mining pit lake would be a terminal sink, with net evaporation from the lake exceeding the contributions from precipitation and runoff into the lake. The net loss from the high evaporation rate would be balanced by influx of groundwater into the lake. The components of the pit lake water balance at the end of the post-mining simulation are summarised in Table 11-5. Precipitation accounted for nearly two-thirds of the predicted lake inflow, runoff from the pit walls approximately one-third, and groundwater inflow accounted for only a small part of the predicted inflow. The only predicted outflow from the pit lake was through evaporation.

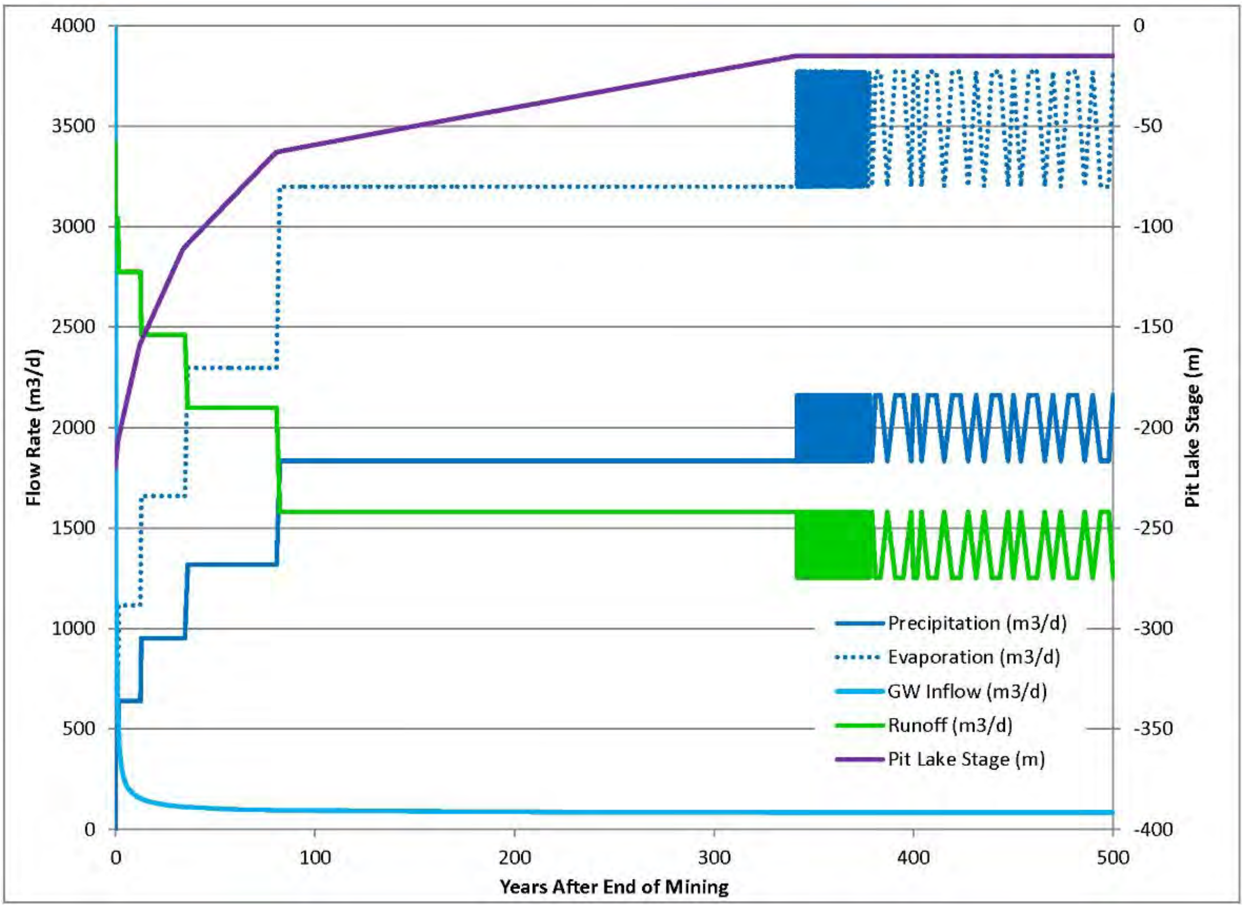


Figure 11-8 Predicted Batman Pit Mine Water Balance

Table 11-5 Summary of Pit Lake Water Balance at End of Simulation

	Average Rate (m^3/d)	Percent of Total Inflow or Outflow
Inflows		
Direct precipitation	2161.47	61.80%
Groundwater inflow	83.74	2.39%
Pit wall runoff	1252.51	35.81%
Total inflow	3797.72	
Outflows		
Evaporation	3770.10	100.00%
Groundwater outflow	0.00	0.00%
Total outflow	3770.10	
Inflow – outflow	27.62	
Percent discrepancy	-0.73%	

Predicted Groundwater Drawdown – Mining Phase

Figure 11-9 shows the predicted water table drawdown at the end of mining. The maximum predicted drawdown at the end of mining was approximately 475m, the depth of the pit below the initial steady-state water table. Drawdown was predicted to decrease rapidly with distance from the pit, with the 10m drawdown contour extending to the pit rim. The 5m and 1m drawdown contours encompass the TSF1 area, primarily because TSF1 was simulated with a head of 136m AHD. TSF1 will be removed from service after five years of mining and was removed as a seepage source at that point in the simulation.

The predicted 1m drawdown contour extended approximately 300m northwest and 200m south of the Batman Pit at the end of the mining period. Modelled changes in water level at the locations of several monitoring bores are illustrated in Figure 11-10. Water level change was predicted to be less than 1m for locations BW17P near the north side of the project area, SW4MB02 adjacent to the Edith River near the downstream side of the project area, or WDMB02P near RP1.

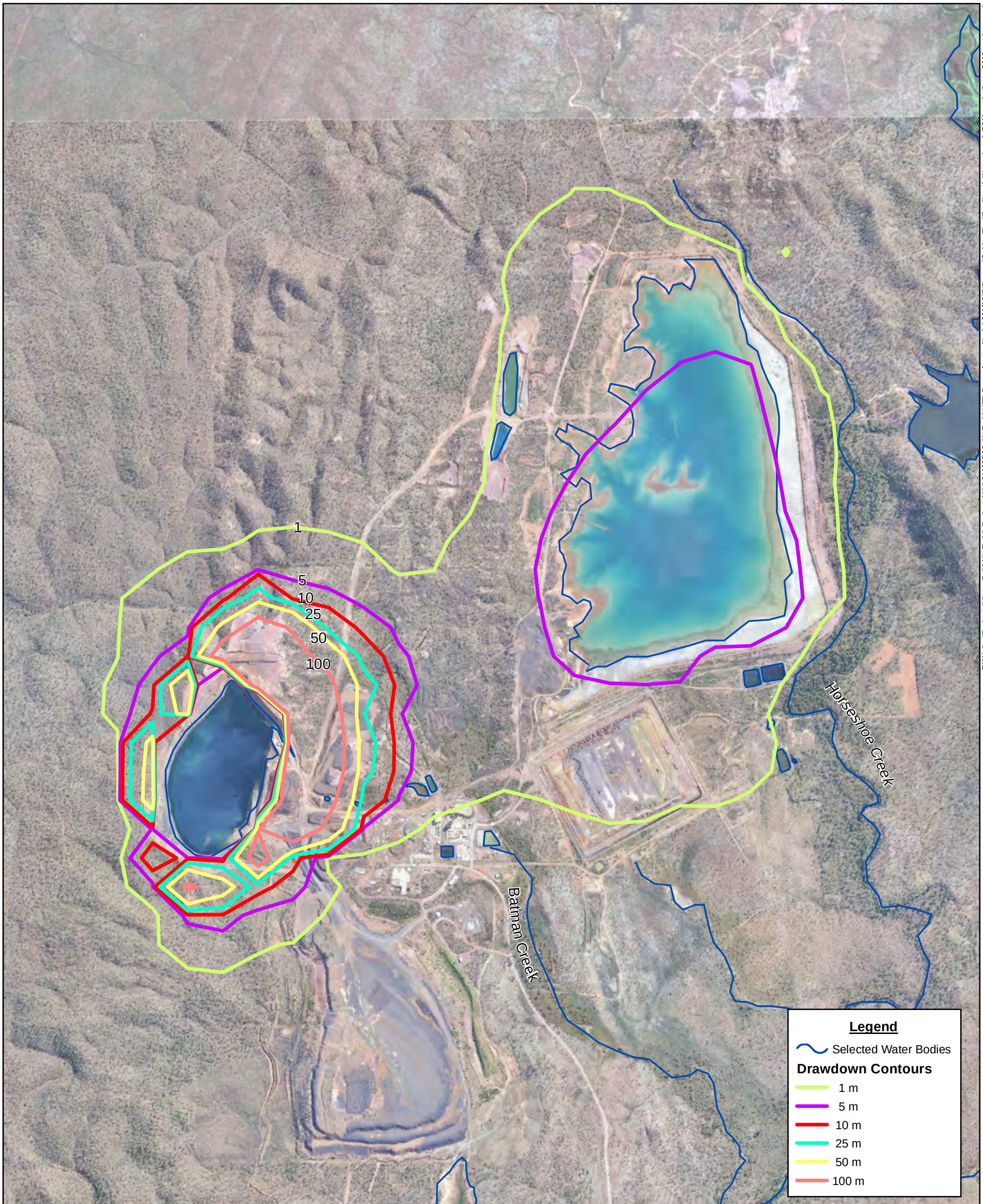
The water level BW1P, east of Batman Pit and south of TSF1 was predicted to rise while TSF1 is active during the first five years of mining and then decline to approximately 1.5m below its initial level by the end of the mining period. Water levels at BPMB01 and BPMB02 near the Batman Pit were predicted to decline in response to pit dewatering during mining.

Predicted Groundwater Drawdown – Post-mining Phase

Because the post-mining pit lake surface is lower than the surrounding groundwater level, it will constitute a long-term hydraulic sink that will draw groundwater in from the surrounding area. Figure 11-11 shows the predicted water table elevation contours 500 years after mining. The inferred directions of groundwater flow are also illustrated. Groundwater is predicted to enter the pit from all sides. A groundwater divide is predicted to form south and southeast of the pit, separating groundwater flow toward the pit from groundwater flow toward Stow Creek and the Edith River.

As the water level in the pit lake recovers toward the predicted equilibrium elevation of 15m AHD, the drawdown cone of depression around the pit lake would become shallower but continue to expand laterally as it equilibrates with the groundwater inflow induced by the evaporative loss from the pit lake. The area predicted to be affected by 1m or more of drawdown within the 500-year post-mining simulation period was limited to a portion of the mine lease area. The predicted 1m drawdown contours for 10, 50, 100 and 500 years after the end of mining are shown on Figure 11-12.

The 1m drawdown contour was predicted to extend on the northeast to between Horseshoe Creek and the RWD, where drawdown would be limited by seepage from the dam, and on the north to approximately 1,500m north of TSF1. In those directions, the extent of the area affected by 1m or more of drawdown remained relatively stable throughout the post-mining simulation period. In the areas north, west and south of the Batman Pit, the 1m drawdown contour migrated laterally outward, ultimately reaching distances of less than 1,500m from the pit rim.



T:\Mining\Projects\Vista_Gold-Mt_Todd_Projects\114-311285.02_Mt Todd UFS Groundwater Model 2012\GIS\figures\GoldenFigs\Predicted_Water-Level_EOM.mxd June, 2013: andrew.york

SCALE IN METRES

0 250 500

1 centimetre = 250 metres

GDA 1994 MGA ZONE 53

NOTES:

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TITLE:

PREDICTED DRAWDOWN AT END OF MINING OPERATIONS

A

REVISION

ISSUED FOR:

VISTA GOLD CORP.

ISSUED BY:

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350 Indiana Street, Suite 500
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(303) 217-5700 (303) 217-5705 fax

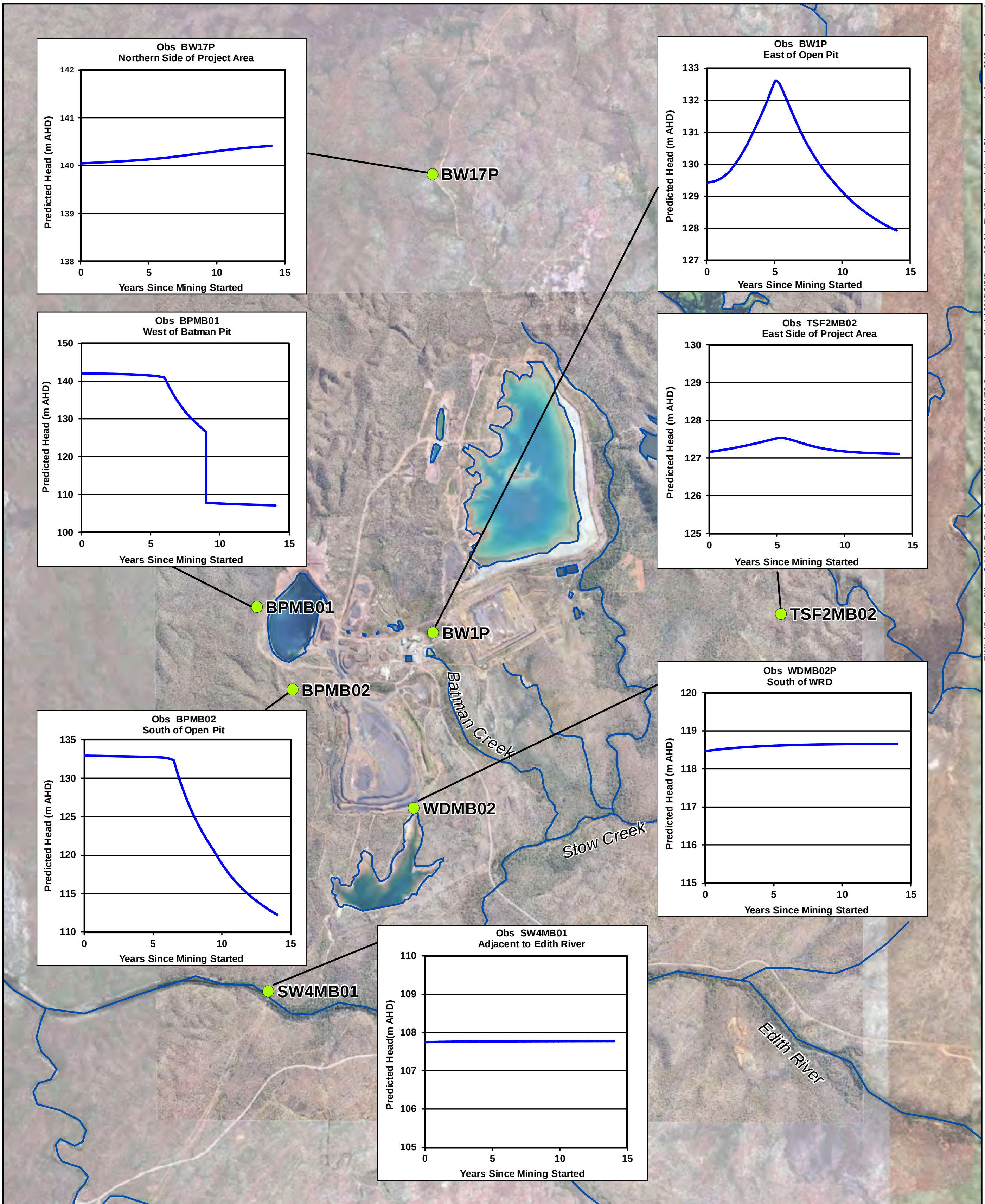
PROJECT: MT. TODD GROUNDWATER MODEL

LOCATION: NORTHERN TERRITORY, AUSTRALIA

PROJECT NO.: 114-311285.02

DATE: 05/2013

Figure 11-9



T:\Mining\Projects\Vista_Gold-Mt_Todd_Projects\114-311285.02_Mt Todd UFS Groundwater Model 2012\GIS\figures\GoldenFigs\Predicted_Head_Changes.mxd June, 2013: andrew.york

SCALE IN METRES

0 500 1,000

1 centimetre = 500 metes

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TITLE:

PREDICTED HEAD CHANGES AT OBSERVATION LOCATIONS

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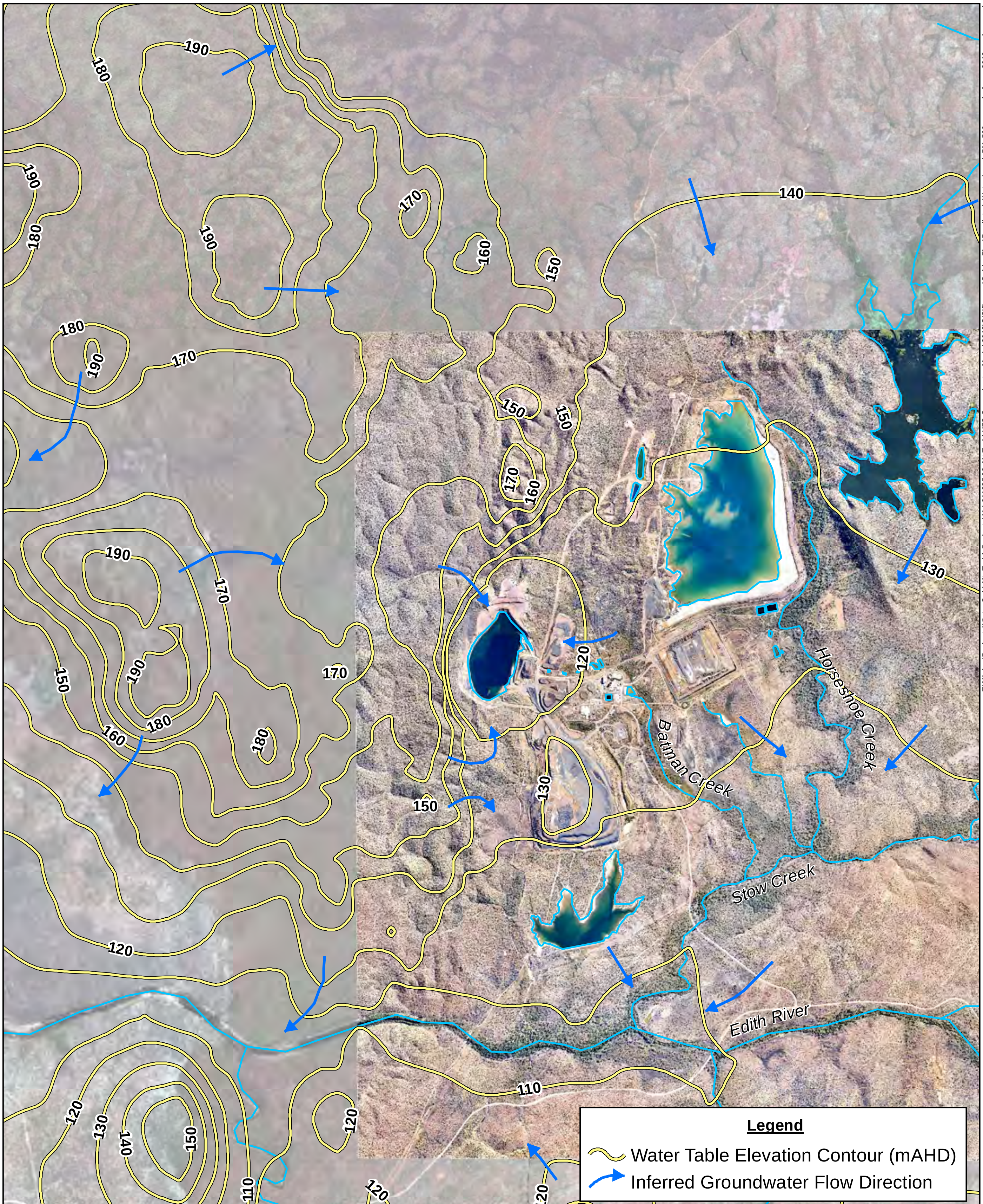
PROJECT: MT. TODD GROUNDWATER MODEL

LOCATION: NORTHERN TERRITORY, AUSTRALIA

PROJECT NO.: 114-311285.02

DATE: 05/2013

Figure 11-10



SCALE IN METRES

0 500 1,000

1 CENTIMETRE = 500 METRES

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TITLE:
PREDICTED WATER TABLE ELEVATION 500 YEARS AFTER END OF MINING

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(303) 217-5700 (303) 217-5705 fax

PROJECT: MT. TODD GROUNDWATER MODEL

LOCATION: NORTHERN TERRITORY, AUSTRALIA

PROJECT NO.: 114-311285.02

DATE: 05/2013

Figure 11-11

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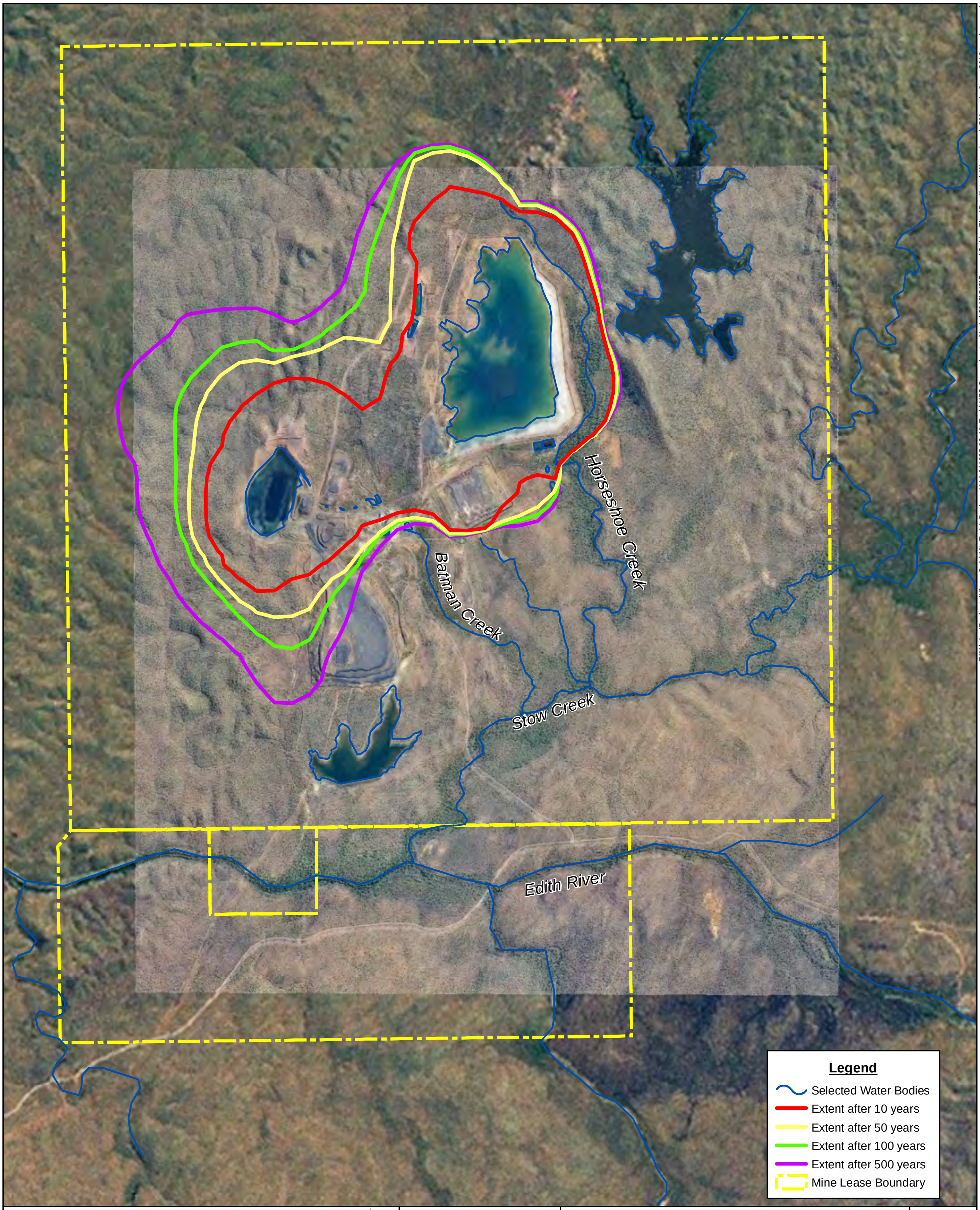

SCALE IN METRES

0 500 1,000

1 centimetre = 500 metres

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NOTES:
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TITLE:
PREDICTED 1M DRAWDOWN DISTRIBUTIONS AT 10, 50, 100, AND 500 YEARS AFTER END OF MINING

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REVISION

ISSUED FOR:
VISTA GOLD CORP.

ISSUED BY:
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(303) 217-5700 (303) 217-5705 fax

PROJECT: MT. TODD GROUNDWATER MODEL

LOCATION: NORTHERN TERRITORY, AUSTRALIA

PROJECT NO.: 114-311285.02

DATE: 05/2013

Figure 11-12

Predicted Surface Water Impacts – Mining Phase

Stream flows were monitored along the Edith River near at three locations detailed on Figure 10-11, including:

- confluence with Stow Creek (Edith River SW4);
- downstream side of the project area (Edith River SW10); and
- lower reaches of Stow Creek (Stow Creek SW3).

Stream flows at all three locations were predicted to increase slightly during the first five years of mining, as the head in TSF1 increased and seepage from TSF1 into the alluvium along Horseshoe Creek likely increased, and then decrease with the decline in heads at TSF1 following its closure (Figure 11-13). The predicted stream flows at the end of mining were reduced from the modelled stream flows at the start of the mining period by 0.02% at both locations along the Edith River and by 0.78% along Stow Creek.

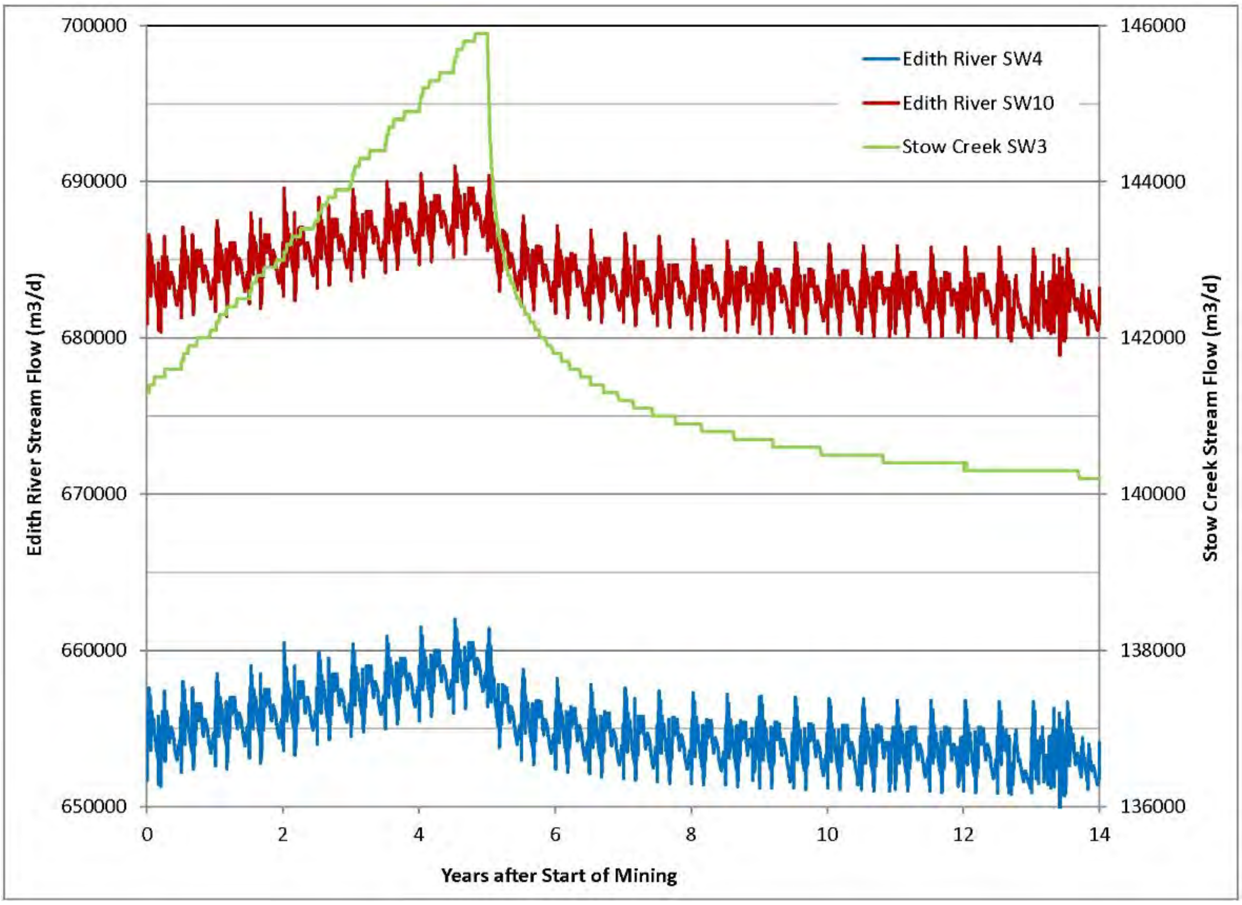

Figure 11-13 Predicted Stream Flows During Mining

Predicted Surface Water Impacts – Post-mining Phase

Stream flow during the post-mining simulation was monitored at the same two locations along the Edith River and the same location along Stow Creek as were monitored during the mining phase simulation. For comparison, both the mining and post-mining flows are included in Figure 11-14. The post-mining flows remained relatively steady. A decrease of 0.06% was predicted to occur at both locations along the Edith River, and a decrease of 0.92% was predicted to occur at the location along Stow Creek.

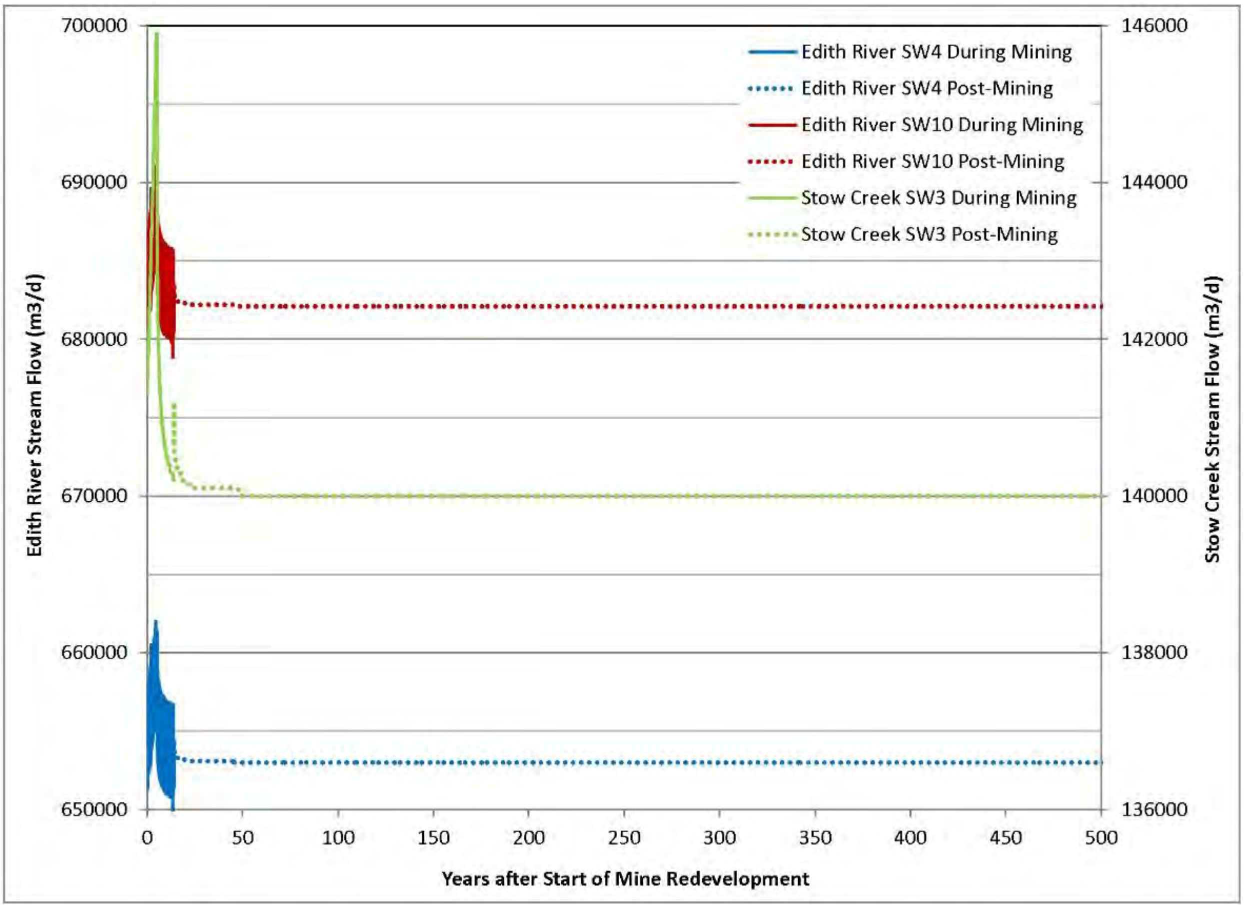

Figure 11-14 Predicted Stream Flows During and After Mining

11.5 Summary of Groundwater Modelling

Potential impacts in the post-mining period will be related to the changes in hydrogeologic conditions caused by the mining activities, including the deepening and enlargement of the Batman Pit, the increased dam height of the RWD, and construction of the lined TSF2. Potential post-mining impacts could include changes in groundwater levels, groundwater flow directions, and stream flows.

RP1 will not change significantly except for a slight decrease in area as the WRD is enlarged to the south. Consequently, no additional impact is anticipated when compared to the baseline condition. The liners of the HLP, the LGO stockpile retention pond, and the plant runoff pond preclude the infiltration of groundwater recharge in those areas, but because the facilities were present under the baseline conditions, their continued presence would not impart additional change during the post-mining period.

The key outcomes from the groundwater modelling are:

- modelled groundwater inflow to the pit is estimated at approximately 30L/s at the end of mining;
- groundwater drawdown during mining was predicted to decrease rapidly with distance from the pit, with the 10m drawdown contour extending only to the pit rim. The predicted 1m drawdown contour extended approximately 300m northwest and 200m south of the Batman Pit at the end of mining;
- drawdown of the local aquifer associated with mining is unlikely to have a significant impact on local groundwater flows into the Edith River and Stow Creek (approximately 0.8% and 0.92% decrease in stream flow during mining and post mining respectively) or to neighbouring groundwater supply bores at Werenbun and Leliyn (Edith Falls);
- the area predicted to be affected by 1m or more of drawdown within the 500-year post-mining period was limited to a portion of the mine lease area adjacent to Batman Pit and TSF1; and
- post-mining the Pit is likely to form a sink pit lake with a water level of 15m AHD, significantly below the surrounding land surface. This is expected to prevent outward migration of pit lake water into and though the aquifer.

11.6 Management Measures

The following management measures are proposed to limit groundwater impacts:

- bores that do not meet the minimum construction requirements for water bores in Australia (LWBC 2003) will be decommissioned or rehabilitated in accordance with the guidelines;
- exploration drill holes that may act as conduits interacting with mine features will be considered for rehabilitation;
- TSF2 will be designed, constructed and rehabilitated in a manner that will minimise oxidisation of sulfides and leakage of contaminated liquor or leachate;
- TSF1, HLP and associated infrastructure will be rehabilitated to either significantly reduce seepage or improve seepage water quality;
- WRD extension will be constructed such that it does not result in significant change to the local groundwater regime and limits the development of AMD;
- the groundwater model will be validated, refined, updated and improved and then used to confirm closure scenario assumptions and to aid closure management decisions; and
- ongoing monitoring to confirm that groundwater impacts are not greater than those predicted.

Ongoing monitoring will include:

- monitoring of groundwater levels (and usage) on neighbouring properties (Edith Falls and Werenbun) and the subsequent development of a series of trigger values to monitor and manage any drawdown or contamination impact resulting from the proposed development;
- geochemical monitoring of a limited set of key groundwater bores (including those deemed ‘background’ or ‘boundary’ bores) on a quarterly basis;
- groundwater monitoring infrastructure will be installed at water retention structures and dumps;
- site water balance data, including pumping, rainfall and stream flows, will be maintained; and
- water levels will be monitored on a quarterly basis in all groundwater monitoring bores on site (or at alternate optimum frequencies based on the fluctuations observed or rates of charge / response).