BIG ISLAND MINING PTY LTD
ABN 12 112 787 470

Dargues Reef Gold Project

GROUNDWATER Assessment

Prepared by

Australasian Groundwater and Environmental Consultants Pty Ltd

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GROUNDWATER Assessment

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EXECUTIVE SUMMARY

Big Island Mining Pty Ltd ("the Proponent") propose to develop an underground gold mine on the Dargues Reef orebody which is located approximately 2.5km north of the village of Majors Creek in south-eastern New South Wales. Mining would be achieved using sub-level, open stoping mining to a depth of approximately 500m, with mined out stopes being backfilled with waste rock. The mine would operate over a five-year period.

A review of existing data from exploration holes, anecdotal information on groundwater occurrence, and data obtained from a field investigation program involving drilling and the establishment of monitoring bores indicates that the hydrogeological regime of the Project Site and surrounds consists of:

- a shallow alluvial aquifer averaging approximately 100m wide and 2-3m deep along Majors Creek;
- a regolith (weathered granodiorite) aquifer extending to approximately 15m depth; and
- a fractured granodiorite aquifer characterized by "tight" massive granodiorite and localized permeable fracture systems.

Thin, narrow bands of colluvial material washed from the relatively steep side slopes occur along the tributary creeks feeding into Majors Creek.

The installation of paired groundwater monitoring bores indicates that the regolith and granodiorite aquifers are hydraulically connected and therefore the groundwater in the regolith is not perched.

Recharge of the regolith and granodiorite is by direct infiltration of rainfall. Groundwater flow and discharge is dominantly to Majors Creek and associated alluvium. A small spring is located in the upper catchment of Spring Creek, a tributary of Majors Creek, the spring water being discharge from the regolith aquifer.

The alluvial deposits along Majors Creek have been extensively altered by historic alluvial gold mining with high mullock heaps in places and exposed bedrock in other sections along the creek. The primary porosity and permeability of the majority of the alluvium has essentially been destroyed by the alluvial mining.

Collection and analysis of groundwater samples from the eight monitoring bores established within the Project Site, and from the former Dargues Reef Mine shaft, indicates that the electrical conductivity of the groundwater within regolith aquifer is in the range 360 - 1300µS/cm, the granodiorite aquifer 530 - 1250µS/cm and the alluvial aquifer 410 - 630µS/cm. The environmental value of the water has been classified in this report as "primary industry" being used primarily for livestock, but there are also some wells that are used for domestic supply. Where permanent flow is maintained by groundwater discharge in Majors and Spring Creeks, the environmental value is classified as "aquatic ecosystems".

A water balance for the Project indicates that of the assessed maximum annual make-up demand for processing, dust suppression etc of 130ML/year, up to 66ML/year will have to be sourced from groundwater. Options for obtaining this supply are from:

- dewatering of the proposed Dargues Reef Mine;
- pumping from existing historic flooded workings approximately 1.2km to the south of the proposed mine;
- dedicated water supply bores.

In order to assess the feasibility of obtaining a groundwater supply and the impact on the groundwater regime of mine dewatering and pumping from the historic workings or a dedicated borefield, a numerical groundwater flow model was developed and calibrated using the MODFLOW SURFACT code. The model was calibrated to steady state water levels measured from the eight monitoring bores and 35 open exploration holes covering the Project Site. There was no long term monitoring data to enable calibration to transient conditions.

The predictive simulation and an assessment and conclusions reached from these simulations are summarised below:

INFLOW TO DARGUES MINE AND DEWATERING OF HISTORIC WORKINGS

Predictive numerical modelling has shown that:

- groundwater inflow to the Dargues Reef Mine would vary between approximately 8L/s and 10L/s during the first two years of mining as the decline is driven to total depth; and
- in subsequent years that is Years 3 – 5 inflow would decrease to approximately 7L/s.

Up to 1L/s of the inflow would be lost through the mine ventilation systems and as moisture with the ore. Therefore theoretically the minimum inflow that could be captured by the mine dewatering systems is 6L/s. However this is likely to be a conservative overestimate as some faults may act as barriers to groundwater flow. Therefore in developing a mine water balance, it is recommended that 4L/s be adopted as groundwater that could be captured and re-used from dewatering of the mine.

As the specific yield (storativity) of the granodiorite is not known it was assumed that it would range between 0.001 and 0.01. Modelling indicates that changing the specific yield of the granodiorite only impacts flow in the first two years of mining when some of the inflow is derived from aquifer storage. In subsequent years inflow is derived from rainfall recharge of the regolith and granodiorite aquifers and steady state inflow for both values of specific yield is approximately 7L/s.

Simulation of pumping from the former Snobs, Stewart and Mertons and United Miners shafts indicate that a groundwater supply of approximately 79ML/year (2.5L/s) could feasibly be obtained from these sources with a drawdown near Majors Creek to RL620m, approximately 12m below the bed of the creek.

A license will be required for mine dewatering and to pump water from the old shafts.

IMPACT ON WATER TABLE/PIEZOMETRIC SURFACE AND GROUNDWATER USERS

Predictive modelling indicates that the radius of influence of dewatering the mine and pumping from the old shafts, as indicated by the 1m drawdown contour, extends up to 2.5km from the proposed mine. Any existing groundwater users within this area of influence would be impacted, with groundwater levels in their bores/wells, and potentially yields, declining.

The NSW Office of Water bore database was searched and a bore census undertaken to locate any bores/wells within the area that may be impacted.

There are 13 registered bores within a 5km radius and the census located 25 bores and wells, some of which may be included in the list of registered bores. The majority of bores/ wells are located within the township of Majors Creek and are beyond the predicted zone of influence of mine dewatering as defined by the 1m drawdown contour. There are two wells in the upper catchment of Shingle Hut Creek which are within the radius of influence of the mine and are likely to be impacted. As they are wells they may go dry if they are relatively shallow. Similarly there are three bores in the upper catchment of Jembaicumbene Creek near the 1m drawdown contour. However, these bores are unlikely to go dry as they are deep wells.

IMPACT ON MAJORS AND SPRING CREEKS AND EMBARGOED WATER

Predictive modelling has shown that the impact of mining reduces discharge from the granodiorite and regolith aquifers to the alluvium of Majors Creek by approximately 1.7L/s due to drawdown created by mine dewatering and pumping from the old shafts and flattening of the hydraulic gradient to the creek. Discharge to the colluvium and spring of Spring Creek will also be reduced by approximately 0.3L/s. That is, there is a total reduction of groundwater discharge from the regolith and granodiorite of approximately 2L/s. This groundwater from the deeper aquifers is not embargoed and is intercepted by mine dewatering and pumping from the old shafts before it reaches the alluvium and becomes embargoed water.

There will however be a reversal of groundwater flow over a very small area of Majors Creek where groundwater in alluvium will leak to the underlying bedrock at a rate of approximately 0.1L/s (3.2ML/year). This water is embargoed and mitigation options to account for the 3.2ML/year of embargoed water captured by the mine include:

- purchase an existing licence from another groundwater user, or
- discharge water into the creek at a rate of 0.1L/s from the dams constructed on the Project Site to harvest surface runoff.

It is assessed that groundwater discharge to Spring Creek would cease during mining and for up to three years post mining, and that the spring in the upper catchment of the creek would also dry up.

IMPACT ON ARALUEN WATER SUPPLY

The Department of Land and Water Conservation has estimated that the total sustainable yield of unconsolidated aquifers in the Araluen River catchment, of which Majors Creek is an upper catchment tributary, is between 8 028 and 8 218ML/year. The overall reduction in the alluvial groundwater of Majors Creek that may eventually flow 20km downstream to Araluen is approximately 2.1L/s (66ML/year) or 0.8% of the sustainable yield. This comprises the 2L/s reduction in discharge from the regolith and granodiorite aquifers and 0.1L/s leakage from the alluvium. However given the distance of Araluen from the Project Site and that the sustainable yield of the alluvium and regolith at Araluen is dominated by local recharge; it is assessed that the Project would have no impact on groundwater supply at Araluen.

IMPACT ON GROUNDWATER QUALITY

The Nett Acid Generating potential of the waste rock that will be stockpiled and used to backfill the stopes is <0.1 H_2SO_4/tonne and as such acid mine drainage is not an issue, and groundwater quality both in the granodiorite, regolith and alluvial aquifer system should not be impacted.

GROUNDWATER RECOVERY

The model simulations have shown that groundwater levels around the Dargues Reef Mine will recover rapidly within three years of cessation of mining based on the assumption that the stopes are backfilled with waste rock and that the consequent void space in the mine is 35% of the slope volume. The recovery of the last few metres to pre-mining groundwater levels will take in excess of 5 years post mining.

GROUNDWATER MONITORING PLAN

A groundwater monitoring plan has been designed to provide timely warning of any unpredicted or adverse impacts so that remedial actions can be taken.

1. INTRODUCTION

Big Island Mining Pty Ltd (the Proponent), a wholly owned subsidiary of Cortona Resources Limited (Cortona), proposes to develop an underground gold mine operation at Majors Creek in south-eastern New South Wales. The proposal, the Dargues Reef Gold Project here-in-after referred to as "the Project," will be developed at the historic Dargues Reef Mine. The historic mine workings are limited in extent and are currently flooded. The Project comprises an underground gold mine, a processing plant, a temporary waste rock emplacement and a tailings storage facility, as well as ancillary activities and associated infrastructure.

The Proponent is applying to the Minister of Planning for Project Approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act), and R.W. Corkery & Co. Pty Limited (RWC) have been commissioned to prepare an Environmental Assessment (EA) in support of the Part 3A Project Application. This groundwater assessment has been completed by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) at the request of RWC on behalf of the Proponent.

2. PROJECT OVERVIEW

The Project would be developed entirely within the Project Site, with is located approximately 13km to the south of Braidwood, in the vicinity of the village of Majors Creek (**Drawing No. 1**). The Project would comprise the following components.

- Extraction of waste rock and ore material from the Dargues Reef deposit using underground sublevel open stope mining methods to a depth of approximately 500m below surface with a suitable crown pillar to prevent surface subsidence.
- Construction and use of surface infrastructure required for the underground mine, including a box cut, portal and decline, magazines, fuel store, ventilation rise and power and water supply.
- Construction and use of a processing plant and office area which would include an integrated Run-of-Mine (ROM) pad/temporary waste rock emplacement, crushing and grinding, gravity separation and floatation circuits, Proponent and mining contractor site offices, workshop, laydown area, ablutions facilities, stores, car parking, and associated infrastructure.
- Construction and use of a tailings storage facility.
- Construction and use of a water management system, including construction and use of eight dams and associated water reticulation system, to enable the harvesting and supply of water for mining-related operations. It is noted that the proposed water harvesting operations would be consistent with the Proponent's harvestable right.
- Construction and use of a site access road and intersection to allow site access from Majors Creek Road.
- Transportation of sulphide concentrate from the Project Site to the Proponent's customers via public roads surrounding the Project Site using covered semi-trailers.

- Construction and use of ancillary infrastructure, including soil stockpiles, core yards, internal roads and tracks and surface water management structures.
- Construction and rehabilitation of a final landform that would be geotechnically stable and suitable for a final land use of agriculture and/or nature conservation.

With respect to operational water supplies, it has been estimated that the Project will require approximately 130ML/y of new or makeup water for processing, dust suppression, underground mining operations and workshop wash-down purposes. This will be obtained from the Proponents harvestable rights of surface water and dewatering of the proposed Dargues Reef Mine, with the shortfall in supply to be sourced from groundwater obtained from other flooded, underground, historic mines within or adjacent to the Project Site.

3. SCOPE OF WORK – DIRECTOR GENERAL'S REQUIREMENTS

The Director General's Requirements of each government department in relation to groundwater and where they are addressed in this report are given in **Appendix 1**, and a summary of the requirements for the groundwater assessment provided by NSW Office of Water (NOW) is given below.

- Identification of site water demands and water sources (surface and groundwater).
- Adequate and secure water supply.
- A detailed groundwater model.
- Detailed analysis of the impacts of dewatering if required for the project, identifying:
  - intercepted and dewatered volumes throughout the mine life;
  - the areal extent of piezometric level drawdown;
  - the likely quality of extracted groundwater;
  - alterations to site water balance;
  - impact on adjacent licensed water users, basic landholder rights, groundwater-dependent ecosystems and the surface water environment;
  - any identified connected water sources impacted by mining; and
  - post mine life recovery period to reach equilibrium.
- Adequate mitigating and monitoring requirements to address groundwater impacts. This is to include an outline of a proposed groundwater management plan to meet licensing requirements.
- Identification of works or activities requiring licensing under the *Water Act 1912* or *Water Management Act 2000*, eg. Monitoring bores, aquifer interception, groundwater and/or surface water extraction.

4. LEGISLATION

The following section outlines New South Wales State legislation, policy and guidelines with respect to groundwater that must be addressed in assessing a mining proposal.

4.1 WATER ACT 1912

The issue of licences to install a bore and take water from groundwater sources in those areas where water sharing plans have not commenced is governed by the *Water Act 1912* and managed by the NSW Office of Water. A licence is required for taking and using groundwater entering a mine providing the groundwater is not embargoed. A licence will not be issued for embargoed groundwater that enters a mine or is impacted by mining, and a license covering the volume of embargoed water impacted, must be purchased from an existing licence holder.

4.2 WATER MANAGEMENT ACT 2000

The objective of the *Water Management Act 2000* (WM Act) is the sustainable and integrated management of the State's water for the benefit of both present and future generations. The WM Act provides clear arrangements for controlling land based activities that affect the quality and quantity of the State's water resources. It provides for four types of approval:

- water use approval – which authorise the use of water at a specified location for a particular purpose, for up to 10 years;
- water management work approval;
- controlled activity approval; and
- aquifer interference activity approval – which authorises the holder to conduct activities that affect an aquifer such as approval for activities that intersect groundwater, other than water supply bores and may be issued for up to 10 years.

For controlled activities and aquifer interference activities, the WM Act requires that the activities avoid or minimize their impact on the water resource and land degradation, and where possible, the land must be rehabilitated.

4.3 EMBARGO ON ANY FURTHER APPLICATIONS FOR SUB SURFACE WATER LICENCES

Almost all groundwater in NSW is managed under either a water sharing plan made under the WM Act, or an embargo order made under s. 113A of the *Water Act 1912*.

Embargo orders are made under the *Water Act 1912* and apply until replaced by either:

a) another embargo order made under the *Water Act 1912*, or

b) a water sharing plan made under the *Water Management Act 2000* for the water source.

Where an embargo order applies, an application for a new water licence under the *Water Act 1912* cannot be lodged unless it fits within one of the exemptions specified in the order or in the *Water Act 1912*. Basic landholder rights under s. 52 of the Water Management Act, including domestic and stock rights, as well as groundwater for town and village, community recreational and aboriginal cultural purposes are exempt from the embargo orders. The NOW website states that *the only other way to obtain additional water for new or expanding activities is to purchase an allocation from an existing licence, that is through trading.*

The Project Site is covered by an embargo, gazetted on 11 April 2008, covering the Coastal Floodplain Alluvial Groundwater Sources and Highly Connected Alluvial Groundwater Sources of Coastal Catchments – Regional NSW. Advice received from NOW is that the embargo applies to surface water and alluvial groundwater associated with third order streams or higher. The embargo, however, does not apply to deeper aquifers.

4.4 STATE GROUNDWATER POLICY

4.4.1 Overview

The NSW State Government (1997) Groundwater Policy Framework Document was adopted in 1997 and aims to manage the State's groundwater resources to sustain their environmental, social and economic uses. The policy has three parts, namely the:

- NSW Government (1998a) Groundwater Quality Protection Policy, adopted in December 1998;
- NSW Government (2002) State Groundwater Dependent Ecosystems Policy adopted in 2002; and
- NSW Government (undated) Groundwater Quantity Management Policy advice.

4.4.2 Groundwater Quality Protection

The NSW Groundwater Quality Protection Policy (1998), states that the objectives of the policy will be achieved by applying the management principals listed below.

1. All groundwater systems should be managed such that their most sensitive identified beneficial use (or environmental value) is maintained.
2. Town water supplies should be afforded special protection against contamination.
3. Groundwater pollution should be prevented so that future remediation is not required.
4. For new developments, the scale and scope of work required to demonstrate adequate groundwater protection shall be commensurate with the risk the development poses to a groundwater system and the value of the groundwater resource.
5. A groundwater pumper shall bear the responsibility for environmental damage or degradation caused by using groundwaters that are incompatible with soil, vegetation and receiving waters.
6. Groundwater dependent ecosystems will be afforded protection.

7. Groundwater quality protection should be integrated with the management of groundwater quality.
8. The cumulative impacts of developments on groundwater quality should be recognised by all those who manage, use, or impact on the resource.
9. Where possible and practical, environmentally degraded areas should be rehabilitated and their ecosystem support functions restored.

4.4.3 Groundwater Dependent Ecosystems

The NSW Groundwater Dependent Ecosystems Policy is specifically designed to protect valuable ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations. The policy defines Groundwater Dependent Ecosystems as *"communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater".*

Five management principles establish a framework by which groundwater is managed in ways that ensure, whenever possible, that ecological processes in dependent ecosystems are maintained or restored. A summary of the principles is as follows:

- groundwater dependent ecosystems (GDEs) can have important values. Threats should be identified and action taken to protect them;
- groundwater extractions should be managed within the sustainable yield of aquifers;
- priority should be given to GDEs, such that sufficient groundwater is available at all times to meet their needs;
- where scientific knowledge is lacking, the precautionary principle should be applied to protect GDEs; and
- planning, approval and management of developments should aim to minimise adverse affects on groundwater by maintaining natural patterns, not polluting or causing changes to groundwater quality and rehabilitating degraded groundwater ecosystems where necessary.

4.4.4 Groundwater Quantity Protection

The objectives of managing groundwater quantity in New South Wales are:

- "to achieve the efficient, equitable and sustainable use of the State's groundwater;
- to prevent, halt and reverse degradation of the State's groundwater and their (sic) dependent ecosystems;
- to provide opportunities for development which generate the most cultural, social and economic benefits to the community, region, state and nation, within the context of environmental sustainability; and
- to involve the community in the management of groundwater resources."

4.5 AQUIFER RISK

The NSW Department of Land and Water Conservation (1998)[1] "Aquifer Risk Assessment Report" used a number of criteria to classify risks to various significant groundwater resources across the State. It classified the Southern Tableland Granites and South Coast Fractured Rock Aquifers as "low risk aquifers". There was no classification for the alluvial aquifers of Majors Creek.

5. REGIONAL SETTING AND MINING HISTORY

5.1 LOCATION

The Project is located approximately 13km to the south of Braidwood in the vicinity of the village of Majors Creek, in south-eastern New South Wales. The Project Site comprises an area of 396ha within Exploration Licence (EL) 6003 and encompasses part of the historic Majors Creek goldfield which includes alluvial workings along Majors and Spring Creeks and shafts/underground workings sunk on reef ore bodies. These include the Dargues Reef Mine on which the Project is centralised and underground workings associated with the former Snobs, Stewart and Mertons and United Miners operations, located approximately 1.2km to the south of the Dargues Reef mineralisation.

The Project location is shown **Figure 1** and on **Drawing No. 1**.

5.2 TOPOGRAPHY AND DRAINAGE

The Project Site is located in an area of relatively steeply undulating hills in the Great Dividing Range and generally occurs within the upper part of the Araluen River catchment, although the northern-most sector of the Project Site occurs in the Shoalhaven River catchment (see **Drawing No. 1**). The majority of the site is drained by Spring Creek and its tributaries which discharge into Majors Creek. Shingle Hut and North Creeks which discharge into Majors Creek about 500m upstream of Spring Creek drain a small proportion of the Project Site. Majors Creek passes through and drains the southern sector of the Project Site and is a tributary of Araluen River which has a catchment area of about 180km^2.

Spring Creek and its tributaries are relatively deeply incised and consequently steep sided. As its name suggests a small spring is located in the upper catchment of the creek.

The elevation of the Project Site ranges from about 744m AHD (Australian Height Datum) at the northern boundary to 630m AHD along Majors Creek.

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[1] Department of Land and water Conservation, (April 1998), *"Aquifer Risk assessment Report".* Ref. HO/16/98.

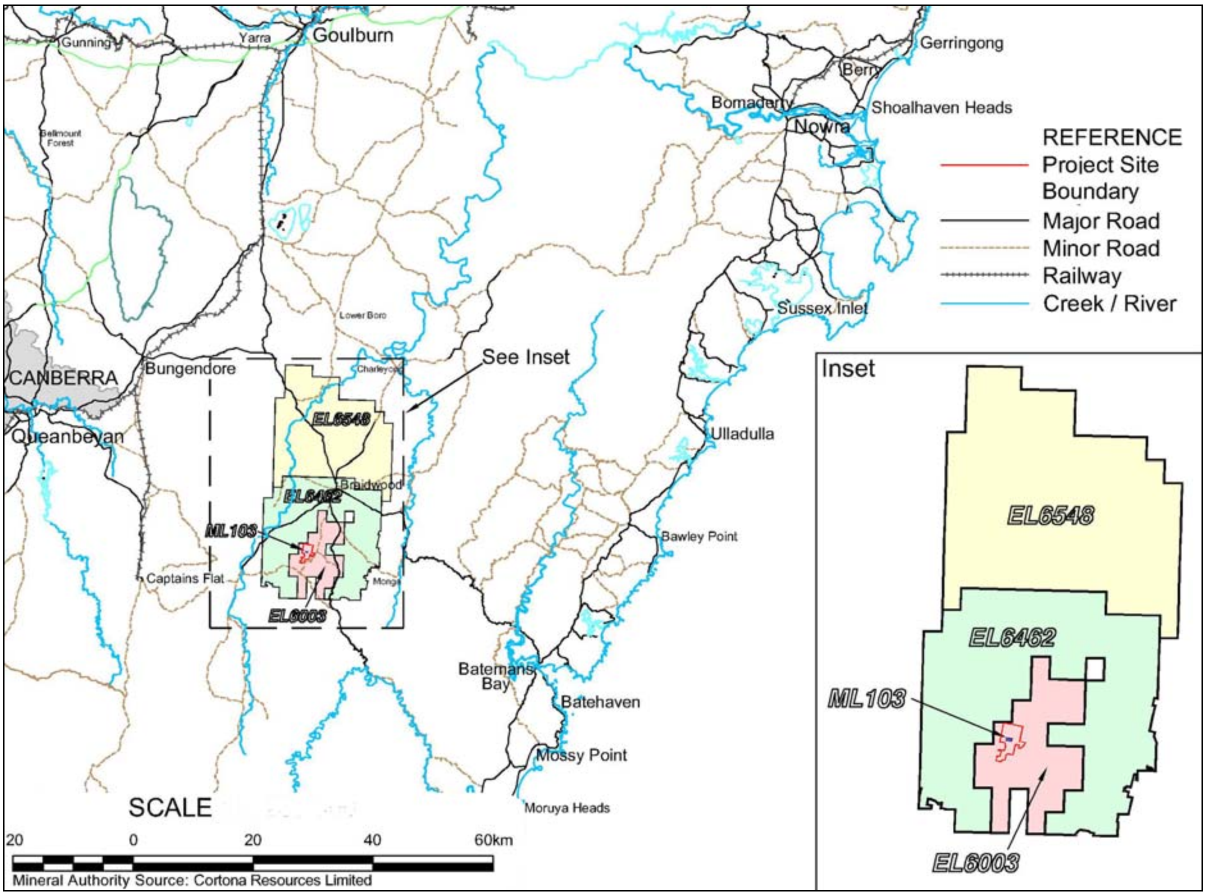

Figure 1 Locality Plan and Mineral Authorities

5.3 LAND USES

A variety of land uses surround the Project Site including:

- Agriculture – primarily grazing of cattle and sheep on areas of the undulating hills that have been cleared for such purposes. The Project Site is primarily contained within land cleared for cattle grazing.
- Native conservation and forestry – primarily restricted to areas of steep slopes and areas unsuitable for other land uses.
- Residential and rural residential associated with the village of Majors Creek to the immediate south of the Project Site.

5.4 CLIMATE

The climate of the area is characterized by mild summers with an average maximum temperature in January of 26ºC and cold winters with July being the coldest month with an average maximum temperature of 11.4ºC and an average minimum of -0.2ºC.

Rainfall records were obtained from the Bureau of Meteorology (BoM) Braidwood Wallace Street Station – Stn No. 069010 (1987 to 2010) located about 12km to the north of the Project Site.

A summary of the climate data is provided in **Table 1**.

Table 1
Climate Average – Braidwood (Wallace St), Stn No. 069010

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Totals
Mean Max Temp (°C)	25.9	25.4	23.1	19.0	15.0	11.8	11.3	13.1	16.4	19.5	22.2	25.1	
Mean Min Temp (°C)	10.9	11.1	9.3	5.9	2.6	0.7	-0.2	0.8	2.7	5.4	7.6	9.6	
Mean Rainfall (mm)	69.4	66.7	68.3	56.0	57.3	66.0	46.7	47.3	50.4	62.5	62.8	64.2	713.9
Mean Evaporation (mm)	145.7	109.2	96.1	66.0	40.3	27.0	31.0	52.7	78.0	108.5	120.0	142.6	1017.1
Evap minus Rainfall (mm)	76.3	42.5	27.8	10.0	-17.0	-39.0	-15.7	5.4	27.6	46.0	57.2	78.4	299.2

Note: i) temperature data for years 1907 – 1975
rainfall data for years 1887 – 2010
evaporation data for years 1996 – 2010

The average annual rainfall is about 719mm per year with rainfall distributed fairly evenly throughout the year. Evaporation exceeds rainfall in most months with the exception of the winter period May to July. On an annual basis evaporation exceeds rainfall by about 300mm.

5.5 HISTORY OF MINING

The history of mining was summarized in the EA and a brief description is given below due to the relevance of the history of this groundwater assessment.

The Majors Creek and Araluen Goldfields, which were worked between about 1850 and 1939, represent the largest alluvial goldfields in NSW, with about 1.25 million ounces of gold being produced, 98% of which was from alluvial workings. Consequently the alluvium along Majors Creek, which forms part of the Project Site, has been highly disturbed with many mullock heaps extending above the natural ground level and in other areas bedrock exposed along the creek where the alluvium has been removed.

The Dargues Reef orebody was discovered in 1870 about midway along Spring Creek and the Dargues Reef shaft was sunk to a depth of 67m. In addition, other shafts were sunk on lodes at the southern end of the Project Site, namely Snobs, Stewart and Mertons and United Miners. All shafts are now flooded from groundwater inflow. **Drawing No. 2** presents a plan showing the location of the former workings.

6. GEOLOGICAL SETTING

6.1 PROJECT SITE GEOLOGY

The geology of the Project Site and surrounding areas presented in this section is derived from the Araluen 1:100,000 Geological Series Sheet.

The Project Site is located within the Lachlan Fold Belt and the site and surrounds are underlain by the Devonian-aged Braidwood Granodiorite, a pluton consisting of multiple intrusions and occupying an area of about 1000km^2. The granodiorite is a medium grained, equi granular hornblende-biotite rich igneous rock. The geological map of the site is shown on **Drawing No. 3**.

The Braidwood Granodiorite intruded the early Devonian-aged Long Flat Volcanics, a felsic extrusive, which outcrops the immediate west of the Project Site. Ordovician-aged sediments form the eastern margin of the granodiorite and occur about 10km to the east of the Project Site.

The upper 10m to 15m of the granodiorite is weathered with a general relatively sharp contact with the underlying fresh rock (G. Cozens pers. com).

Alluvium, consisting of coarse grained arkosic sand and clay and granodiorite boulders has been deposited along Majors Creek, whereas the deposits in the base and sides of the tributary creeks are colluvial material that has washed from the slopes above the tributaries. The alluvium along Majors Creek varies between about 60m and 200m in width and has been extensively worked for gold in the late 1800's, early 1900's. Based on the drilling results from the monitoring bore installations, it would appear to have a maximum thickness of about 3m, although there are thicker sections of reworked alluvium left as mullock heaps during former mining operations. The alluvium appears as relatively uniform, clay rich, arkosic sand with any areas of naturally well sorted material being destroyed by mining activities.

The colluvium in Spring Creek occurs as a very narrow deposit and is less than 0.5m thick in the upper part of the Spring Creek catchment, probably increasing marginally in thickness down-gradient towards its confluence with Majors Creek. There is probably an admixture of alluvium and colluvium near its confluence with Majors Creek.

The alluvium and colluvium grades into underlying weathered to fresh granodiorite.

6.2 STRUCTURE

The Braidwood Granodiorite is cut by a number of north-west, south-east trending, steeply dipping faults that are clearly visible on the aeromagnetic data. The granodiorite is also cut by a second suite of structures striking to the north-northeast. The faults and lineaments shown on **Drawing No. 3** were mapped or interpreted from aeromagnetic data by the Proponent. They are zones of weakness and appear to control drainage patterns within the Project Site and surrounds.

6.3 MINERALIZATION

Gold mineralization at Dargues Reef is structurally controlled and is hosted within east-west trending lenses that maintain a steep southerly dip within strongly altered (sericite-silica-carbonate) granodiorite near the contacts of a sub-vertical diorite to quartz diorite dyke. The lenses follow the east-west fracture system in the granodiorite which is particularly well developed adjacent to the diorite dykes. The location of old mines and workings is shown on **Drawing No. 2**.

The lodes have a width of between 5m and 20m, a strike length of up to 140m and they extend down-dip for at least 450m.

6.4 SUMMARY OF GEOLOGICAL SETTING

In summary the entire Project Site consists of generally massive Braidwood Granodiorite which has been intruded by dykes and hosts the gold bearing ore bodies which occur in east-west striking fracture controlled lodes systems. The upper 10m to 15m of the granodiorite is weathered, with a relatively sharp contact with the underlying fresh rock.

Thin alluvial deposits along Majors Creek have been extensively reworked by historic alluvial gold mining activities and very thin, predominantly colluvial deposits occur as narrow bands along Spring Creek and other tributaries feeding into Majors Creek.

7. FIELD INVESTIGATION PROGRAM

A field investigation program consisting of an initial site visit, installation of monitoring bores, water quality sampling, permeability testing, and water level monitoring was undertaken to obtain data that would define the hydrogeological regime of the Project Site.

7.1 MONITORING BORE INSTALLATION PROGRAM

7.1.1 Program Objective

A review of existing site data indicated that apart from open exploration holes there were no dedicated monitoring bores that would provide data on the groundwater regime. Therefore following an initial site visit, a number of sites were selected for installation of monitoring bores that would also form part of a monitoring network to provide baseline data and monitor the impact of the Project during and following mining. The general objectives of installing monitoring bores were to provide data on:

- the saturated thickness of the alluvium along Majors Creek and the hydraulic connectivity between the alluvium and the underlying granodiorite;
- the hydraulic connectivity of groundwater in the weathered granodiorite and the deeper fractured rock, that is if groundwater in the weathered zone is perched;
- the source of spring discharge in the upper reaches of Spring Creek;
- groundwater quality;
- aquifer permeability (hydraulic conductivity).

7.2 MONITORING BORE CONSTRUCTION

Bungendore Water Bores undertook the drilling, installation and construction of the monitoring bores with instructions for bore depth, screen settings, etc provided by an AGE hydrogeologist. The boreholes were drilled using the rotary air blast (RAB) drilling technique and no drilling fluids or additives were used. Rock chip samples were collected at 1m intervals and logged by a Cortona geologist.

The boreholes were cased with Class 18, 50mm diameter, lead free uPVC casing. Machine slotted uPVC screens were placed at the base of the hole with blank casing back to surface. A clean 3mm to 6mm gravel filter was placed by gravity around the screens, a bentonite seal (½" bentonite pellets), placed above the gravel and the remainder of the annulus sealed with a cement/bentonite grout. A tremie pipe was used to place the grout in the deeper holes. Lockable steel monuments were concreted into the ground around the protruding uPVC casing. Construction of the bores conformed to the requirements of the document *"Minimum Construction Requirements for Water Bores in Australia"* published by the Land and Water Biodiversity Committee (http://www.iah.org.au/pdfs/mcrwba.pdf).

After construction, the monitoring bores were developed using the airlift method until producing clear, sediment free water.

In total 8 monitoring bores were constructed at 6 sites. The location of the bores is shown on **Drawing No. 4**. A pair of monitoring bores were installed at two sites (DRWB01/02 and DRWB03/04), one in the weathered zone (regolith) and the second in the deeper fractured rock, in order to assess the hydraulic connectivity between the two aquifer systems. The deeper bore was drilled first to determine the nature and thickness of the weathered zone and subsequently the shallow bore was drilled and constructed.

A schematic of the typical construction of the monitoring bores is shown in **Figure 2**.

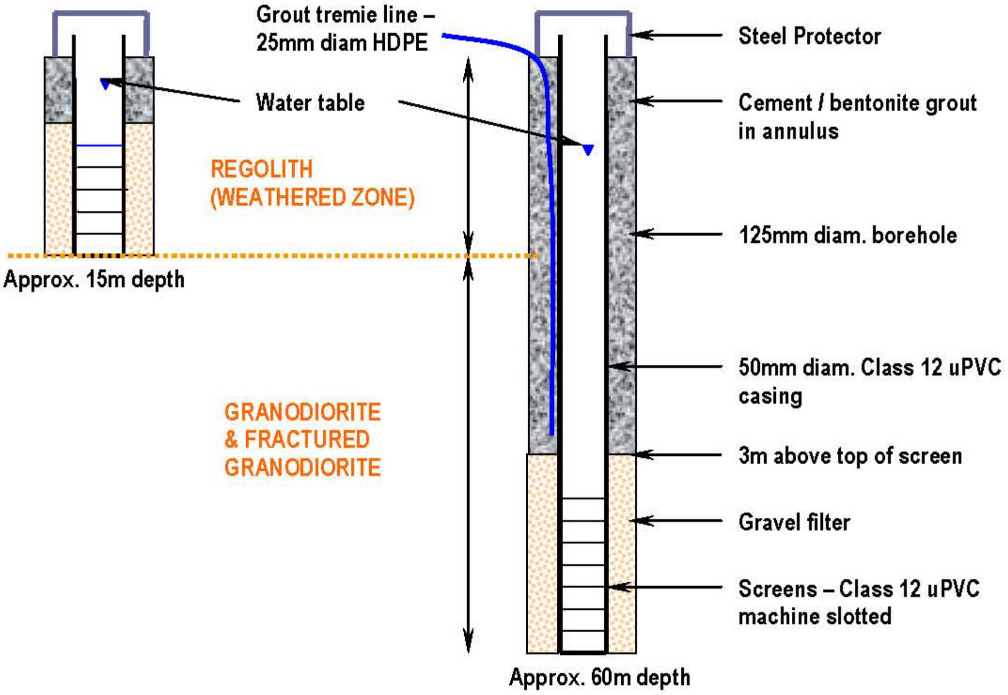

Figure 2 **Schematic of Monitoring Bore Construction**

The construction details of the monitoring bores are summarized in **Table 2** and Composite Bore Logs showing the lithology and construction are given in **Appendix 2**.

Table 2
Summary of Monitoring Bore Construction and Water Levels

Bore	**Location**		**Elevation (RLm)**		**Depth**	**Screen**	**Static Water Level**			**Aquifer**
	mE	**mN**	**Ground**	**TOC**	**(m)**	**(mbGL)**	**Date**	**(mbGL)**	**(RLm)**	
DRWB01	748681.1	6063944.8	714.65	715.20	67	61.0 – 7.0	25/04/10	9.41	705.8	granodiorite
DRWB02	748676.6	6063945.8	714.67	715.24	15.9	9.9 – 15.9	25/04/10	9.42	705.8	regolith
DRWB03	749111.8	6063817.2	712.35	712.91	66.1	60.1 – 66.1	25/04/10	8.64	704.3	granodiorite
DRWB04	749115.8	6063814.4	712.72	713.29	16.5	10.5 – 16.5	25/04/10	8.61	704.7	regolith
DRWB05	749200.3	6063530.7	721.89	721.87	15.58	9.6 – 15.6	25/04/10	dry		regolith
DRWB06	748848.7	6061994.6	632.34	632.98	6.45	3.45 – 6.45	20/04/10	1.24	631.7	alluvium
DRWB07	748724.7	6061835.4	636.72	637.17	11.25	5.25 – 11.25	20/04/10	4.23	632.9	alluvium
DRWB08	749240.0	6061796.4	627.38	628.01	11.22	5.12 – 11.12	20/04/10	1.93	626.1	Alluvium

Notes:
i) TOC = top of casing
ii) mbGL = metres below ground level
iii) co-ordinate projection MGA 94, Zone 56

7.3 WATER SAMPLE COLLECTION AND ANALYSIS

Groundwater samples were collected from the monitoring bores for laboratory analysis by an AGE hydrogeologist using disposable bailers. The bores were purged by bailing and electrical conductivity (EC) and pH monitored using a pre-calibrated conductivity-salinity meter manufactured by TPS. The sample was taken when EC and pH of water being bailed had stabilized and at least 3 bore volumes of water had been removed. The samples designated for metal analysis were filtered in the field.

The groundwater samples were analysed for:

- pH and EC;
- major Anions (CO_3, HCO_3, Cl, SO_4) and Cations (Ca, Mg, Na, K);
- metals suite; and
- nutrients (nitrate, nitrite and total phosphorous).

The results of the laboratory testing are presented and discussed in Section 10.2.

7.4 PERMEABILITY TESTS

As a part of the investigation hydraulic (falling and/or rising head) permeability tests were conducted on the monitoring bores. The tests were designed to evaluate the hydraulic conductivity of aquifer material surrounding the bore screen. Falling and rising head tests require a “slug” of water being poured into or removed from the bore and the rate of decline or rise in water level being monitored. The fall off or rise in water level was monitored using a vibrating wire piezometer set to measure at a minimum 2 second intervals. The test data for each monitoring bore tested is included in **Appendix 3**. The data were analysed by the Hvorslev Method (1951)[2] using *Aquifer Test Version 2.5* software. The results of the analyses are summarised in **Table 3** and discussed in more detail in Section 9.0.

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[2] Horslev, M.J., (1951) *“Time Lag and Soil Permeability in Ground-Water Observations”* Bull.No.36, Waterways Exper.Sta. Corps of Engrs, U.S. Army, Vicksburg, Mississippi, pp1-50.

Table 3
Falling / Rising Head Test Results

Bore ID	**Aquifer**	**Hydraulic Conductivity**	
		m/sec	**m/day**
DRWB01	Granodiorite	5.52×10^{-9}	4.68×10^{-4}
DRWB03		1.01×10^{-9}	8.69×10^{-5}
DRWB02	Regolith (weathered zone)	2.34×10^{-7}	2.02×10^{-2}
DRWB04		1.52×10^{-6}	1.31×10^{-1}
DRWB07	Alluvium/Regolith	6.09×10^{-7}	5.26×10^{-2}
DRWB08		5.60×10^{-7}	4.84×10^{-2}

7.5 BORE CENSUS

A census of privately owned water bores/wells located within the Project Site and surrounding area was undertaken by the Proponent. The purpose of the bore census was to gather information on bores/wells within the potential zone of depressurisation created by dewatering of the proposed Dargues Reef underground mine. The results of the bore census are given in **Appendix 4** and are discussed in Section 10.1.2.

8. PREVIOUS STUDIES

No previous groundwater studies of the area surrounding Majors Creek have been found, however detailed investigations have been undertaken of a similar hydrogeological regime around the township of Araluen located about 20km south-east of the Project Site. Araluen is located on alluvial flats of Araluen River of which Majors Creek is a tributary. The alluvial flats contain historic gold workings and overlie the Braidwood Granodiorite, and as such the groundwater regime is similar to that of the Majors Creek area.

The NSW Department of Land and Water Conservation (DLWC) undertook studies of the groundwater regime around Araluen in 1999[3] and 2000[4], with the objective of developing a groundwater management plan as the township was largely dependent on groundwater and groundwater levels were declining. Field investigations were undertaken to develop an understanding of the groundwater system and address community concerns with respect to water quality, resource availability, extraction and user conflicts. The investigation found that the alluvium at Araluen is up to 10m thick and overlies weathered granodiorite. The majority of groundwater is accessed from the unconsolidated sediments; the alluvium and the weathered granodiorite.

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[3] Pritchard S., (June 1999), *"Araluen Groundwater Status Report",* Dept of Land and Water Conservation (draft).

[4] Pritchard S and Russell G.N., (March 2000), *"Araluen Groundwater Investigation, Water Quality Sampling Report",* Dept. of Land and Water Conservation.

9. GROUNDWATER REGIME – EXISTING ENVIRONMENT

The following description of the groundwater regime – existing environment of the Project Site and surrounds is based on the site geology, data obtained from the field investigation program and resource exploration holes and from the studies undertaken at Araluen which, as discussed, is located in a similar hydrogeological regime dominated by the Braidwood Granodiorite as the Project Site.

9.1 GROUNDWATER OCCURRENCE

Based on the geology and bore data, it is assessed that there are three aquifer systems, viz:

- a shallow aquifer associated with the Majors Creek alluvial deposits, that is an alluvial aquifer system;
- a shallow aquifer within the upper weathered zone (regolith) of the granodiorite; that is a regolith aquifer; and
- an aquifer associated with the fracture systems of the granodiorite, that is a fractured rock aquifer system.

The aquifer systems, their characteristics and relationship (connectivity), are discussed in the following sections.

9.2 FRACTURED ROCK AQUIFER (GRANODIORITE)

9.2.1 Distribution

The granodiorite occurs across the whole of the Project Site and surrounding catchments. As discussed, an aeromagnetic survey has shown major fracture systems within the granodiorite, some of which have been intruded by dykes with which the gold mineralization is associated. The granodiorite can be categorized into the following hydrogeological units:

- hydraulically “tight” massive granodiorite which has little or no primary permeability and which is essentially dry; and
- localised fracture or fault systems which are open and transmit groundwater flow.

9.2.2 Groundwater Yield

Yields from the granodiorite can be quite variable, ranging from very minor seepage up to 2L/s, the former representing “tight” massive granodiorite and the latter an open fracture system. The Proponent reports that some exploration holes drilled in the Dargues Reef area intercepted “strong” or “high” water inflows, which are thought to be related to the fracture system of the orebody and/or the proximity to flooded underground workings.

In summary typical yields from the granodiorite are very low (seepage only) with random higher yields associated within the intersection of a fracture system, the yield depending on the number of fractures intersected and the nature of the fractures, that is the width, extent and interconnection with other fractures, and whether they are open or have been infilled.

9.2.3 Hydraulic Parameters

Rising head tests undertaken on the two deep monitoring bores (>60m deep) (DRWB01 and DRWB02) installed during the field investigation indicated a hydraulic conductivity range of 8.7 x 10^{-5}m/day to 4.7 x 10^{-4}m/day (1.0 x 10^{-9} to 5.5 x 19^{-9}m/s), indicating the rock mass is virtually impermeable. However as stated where open fractures occur the rock is of much higher permeability. Calibration of the numerical model as described in Section 12.4.4 indicates that the fracture zones have a hydraulic conductivity 3 orders of magnitude higher than the rock mass. There has been no field testing to confirm this, but as fracture permeability is likely to be highly variable the results from a few field tests would not be meaningful and therefore the model calibration provides a more uniform average.

9.3 REGOLITH AQUIFERS

9.3.1 Distribution and Yield

The weathered zone or regolith occurs over the extent of the granodiorite rock mass and covers the whole of the Project Site and surrounding catchments. As discussed weathering generally occurs to a depth of about 15m, but may be deeper beneath the major drainage lines of Majors Creek and Spring Creek. The paired monitoring bores installed in the regolith and granodiorite indicate that the two aquifers are in direct hydraulic connection and that groundwater in the regolith is not perched, that is, groundwater levels are the same in both aquifers.

It is reported that groundwater is intersected in exploration holes towards the base of the weathered zone and that yields from this zone are variable but low (G. Cozens pers. com). Monitoring bore DRWB02 and DRWB04 constructed in the regolith provided an airlift yield during development of about 0.2L/s.

9.3.2 Hydraulic Parameters

Falling head permeability tests undertaken on monitoring bores DRWB02 and DRWB04 indicate a hydraulic conductivity range of 2.0 x 10^{-2} to 1.3 x 10^{-1}m/day (2.3 x 10^{-7} to 1.5 x 10^{-6}m/s) which is consistent with the yield obtained from the bore. The low permeability and low yield are consistent with the weathered material being described as limonite/haematite stained decomposed granodiorite consisting of partially weathered feldspar, quartz and hornblende.

9.4 ALLUVIAL AQUIFERS AND COLLUVIUM

9.4.1 Distribution

Alluvium consisting of arkosic sand and clay with granite boulders occurs along Majors Creek where it has been extensively reworked by alluvial gold mining. This has resulted in thick mullock heaps in some areas and exposed bedrock in other areas of the creek bed, as shown on **Figure 3**. Three monitoring bores were established in the alluvium of Majors Creek, namely DRWB06, DRWB07 and DRWB08 which indicate a thickness of alluvium or reworked material over weathered granodiorite of 1m, 6m and 5m respectively, with the saturated thickness varying from 0.3m to 3.7m. Monitoring bore DRWB07 which penetrated 6m of alluvium was drilled on the top of a flat mullock heap (see photo in **Appendix 2**), and that actual thickness of in-situ alluvium at this site prior to gold mining was probably only 2m to 3m.

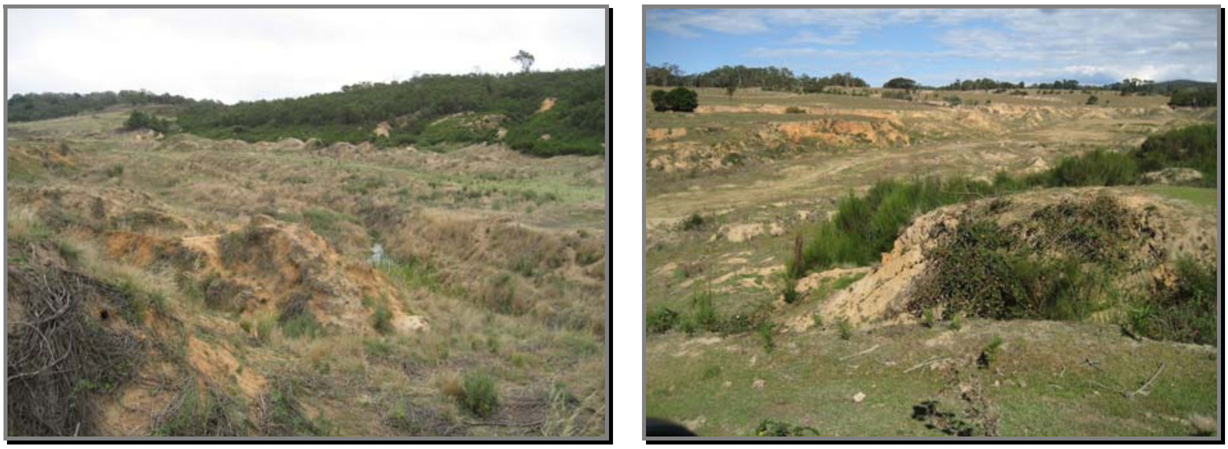


Figure 3 **Alluvium and Mullock Heaps of Reworked Alluvium along Majors Creek**

The alluvium along Majors Creek varies between about 60m to 200m in width, with an average width of about 100m, as indicated by mapping undertaken by the Proponent shown on **Drawing Nos. 3, 4** and **5.**

The mapping also shows narrow bands of colluvium along Spring Creek and other tributary creeks which have been deposited as colluvial slope wash over regolith. The colluvium is generally less than 1m in thickness.

9.4.2 Groundwater Yield

As stated, the alluvium along Majors Creek has been reworked by gold mining and is of relatively thin saturated thickness. Airlift yields during development of the three monitoring bores were less than 0.75L/s.

With the exception of Spring Creek, the colluvium is generally unsaturated except after rainfall runoff events. The colluvium along Spring Creek contains groundwater as a result of discharge from the spring located in the upper part of the catchment.

9.4.3 Hydraulic Parameters

Falling head permeability tests were undertaken on the two monitoring bores that intersected the greatest thickness of alluvium, DRWB07 and DRWB08. These bores were screened in the alluvium and partly in the underlying regolith material, but the gravel filter in the annulus extends over the fully saturated thickness of alluvium. The falling head tests indicated a hydraulic conductivity of about 5×10^{-2}m/day (6×10^{-7}m/sec) which is quite low, consistent with the alluvium being weathered arkosic sand, clay and granodiorite boulders. The falling head tests indicate that the alluvium has a similar, although slightly lower permeability than that of the regolith which is probably indicative of the fact that much of it has been reworked by gold mining, destroying any clean, permeable sand and gravel channels.

9.5 SPRING CREEK SPRING

As its name suggests, a spring is located on Spring Creek in the upper part of the catchment at 74119mE, 6063864mN (MGA94, Z56). The spring occurs as minor seepage in the bed of the creek which is quite steeply incised, as shown on **Figure 4**. Flow in Spring Creek is measured periodically by the Proponent using a 90º V-notch weir established on a concrete pipe culvert that passes under an access track, which crosses the creek in the vicinity of the Dargues Reef workings. The V-notch weir shown on **Figure 4** is located at 749004mE, 6063011mN (MGA94, Z56), about 1km downstream of the spring.

The flow data recorded from the V-notch weir is shown on **Figure 5** together with rainfall data collected from the weather station established by the Proponent. The flow data indicates that surface runoff from rainfall events is the prime contributor to flow in Spring Creek. As discussed the spring appears as minor seepage only in the base of the creek, forming a wet/damp area with associated vegetation. The flow data indicates base flow in Spring Creek, that is groundwater discharge, is less than about 0.3L/s.

Figure 4 Spring Site on Spring Creek (left), V-Notch Weir to Measure Creek Flow (right)

9.6 RECHARGE, GROUNDWATER FLOW AND DISCHARGE

Pritchard and Russell (2000)[4] state that *“for the Araluen area comparison of rainfall data with recorded groundwater levels from the nine DLWC monitoring bores, shows a rapid response of both the alluvial and weathered granodiorite aquifer systems to precipitation events*”.

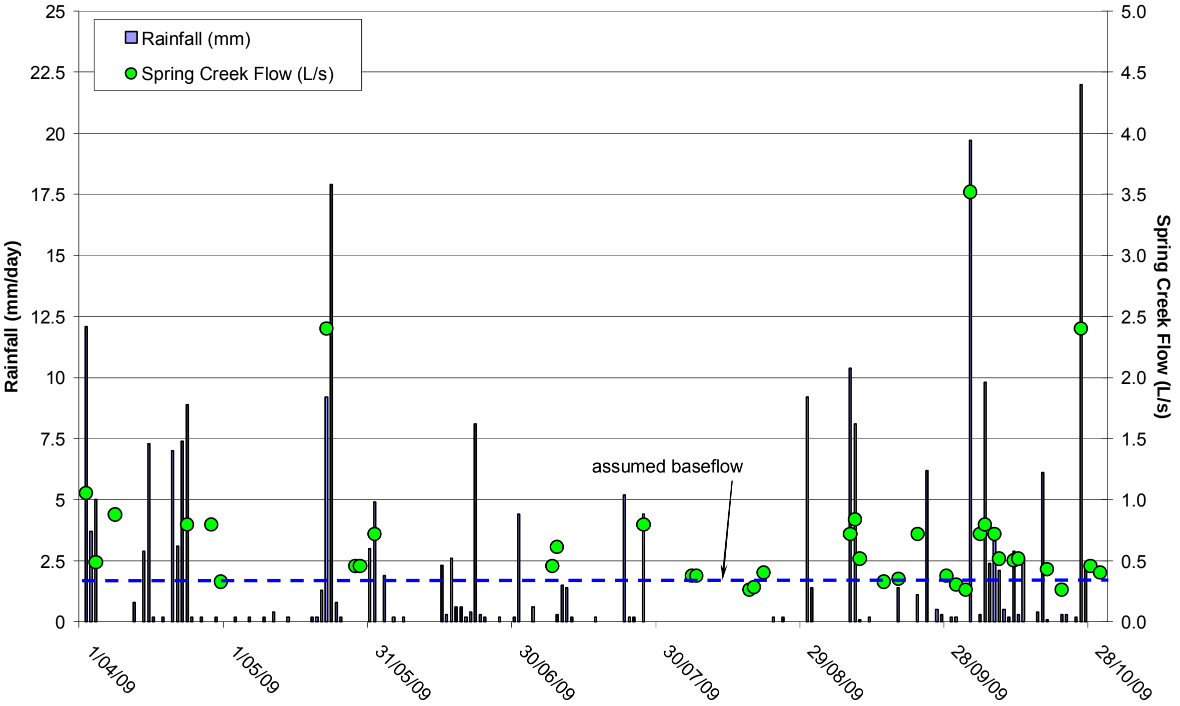


Figure 5 Spring Creek - Spot V-Notch Weir Flow Measurements – vs – Rainfall

The regolith and fractured granodiorite aquifer systems depend on rainfall for recharge with rainfall infiltrating the regolith and gradually migrating to the fractured rock system. Monitoring has shown that the regolith and fractured rock system are in hydraulic connection with water levels in the paired monitoring bores installed by the Project showing the same elevation, that is, groundwater in the regolith is not perched.

The water table is a subdued reflection of the topography, with an elevated water table in topographically high areas grading towards the creeks and steeply incised gullies. Water level data from the monitoring bores and open exploration holes indicate a water table elevation of about 715m AHD in the northern sector of the Project Site, grading to about 663m AHD at Dargues Reef and to about 630m AHD at Majors Creek. The water table contours and the bores and groundwater levels measured in the bores, used to develop the contours, are shown on **Drawing No. 5**. The water level data are summarized in **Appendix 5**.

The groundwater flow direction is from the area of elevated water table towards the gullies and creeks, with Majors Creek being the prime discharge zone of the regolith/fractured granodiorite in the Project Site. Spring Creek is also a groundwater discharge area and as its name suggests, and as discussed, contains a small spring in its upper catchment as shown on **Drawing No. 4**.

The alluvium in Majors Creek is primarily recharged by discharge from the regolith and fractured rock aquifer system. The alluvium may also be recharged by surface runoff from the side slopes of the creek and direct rainfall on the alluvium provides a minor contribution to recharge.

It is assessed that flow in Majors Creek for the majority of time is baseflow, primarily associated with discharge from the regolith/fractured rock aquifer system, and to a lesser extent by discharge from the alluvium.

Based on isotope analysis DLWC (2000)[4] concluded that at Araluen less than 40% of the flow in Araluen River was from rainfall (surface runoff), with the larger component being from shallow or deep groundwater, that is discharged from the aquifers.

10. GROUNDWATER USE, QUALITY AND ENVIRONMENTAL VALUE

10.1 GROUNDWATER USE

10.1.1 NOW Database

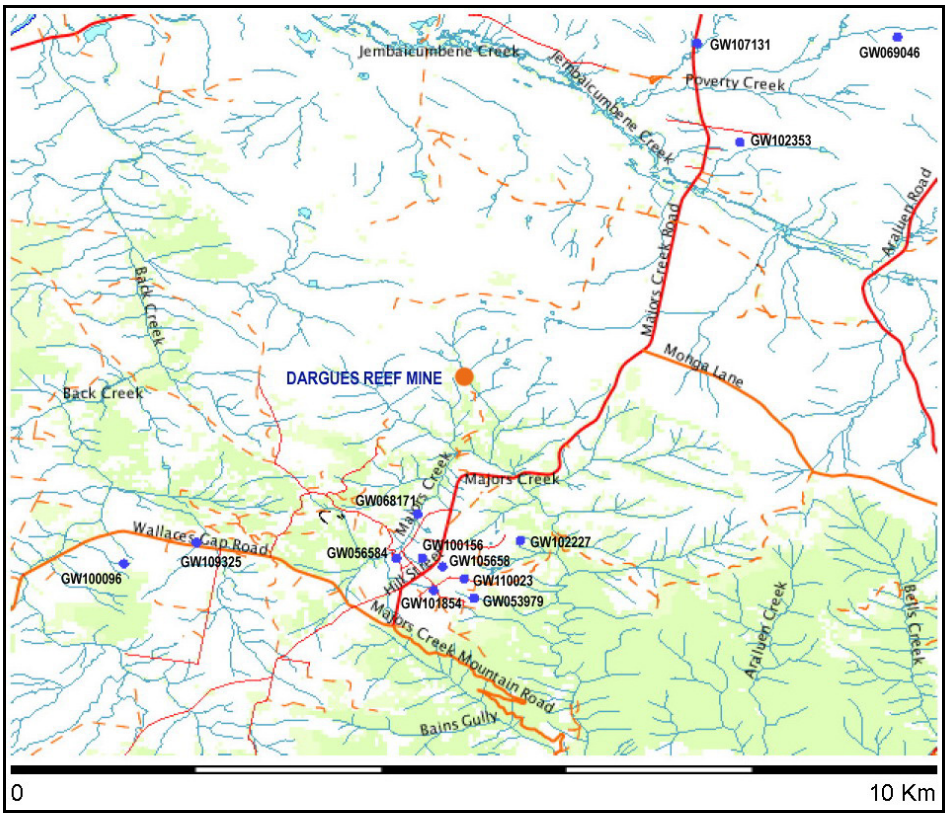
A search of the NSW Office of Water (NOW) database of registered bores and wells within a 5km radius of the Project area indicates that there are 13 registered bores within this radius, as shown on **Figure 6** and summarized in **Table 4**. **Figure 6** indicates that the nearest registered bore is about 1.5km from the proposed Dargues Reef Mine and that the majority are located within the township of Majors Creek. The registered bores are primarily licensed for domestic/stock use although one has an irrigation license. The prime aquifer is fractured granite and yields from the bores are generally less than 0.5L/s. The water quality is reported to be good to fresh.

10.1.2 Bore Census

In recognition that not all existing bores are registered, a census of existing privately owned bores and wells was undertaken by the Proponent in the area surrounding the Project Site. A total of 25 bores or wells were located, of which 11 are within the township of Majors Creek as shown on **Drawing No. 9**. A number of these bores/wells may be the same bores as those registered with NOW, shown on **Table 4** above, the majority of which are also located in the township of Majors Creek, but there is insufficient data to know which ones.

The bore census indicates that the majority of bores are within regolith or granodiorite and that only one or two are in the alluvium of Majors Creek. The facilities vary from shallow wells to bores greater than 30m deep and the uses appears to vary from stock watering to watering of gardens and in one case (Bore No. 3), the water is used for human consumption.

The bore census data is given in **Appendix 4.**



Map created with NSW Groundwater Works – http://nratlas.nsw.gov.au

Figure 6 **Plan showing NOW Registered Bores**

Table 4
Registered Bores within 5km Radius of Project Site

Registered No.	Licence No	Location (mE)	Location (mN)	Depth	Yield (L/s)	Salinity	Aquifer	Purpose
GW068171	10BL145435	6061192	748395	30.5	0.5	good	rock	Domestic/stock
GW102227	10BL143300	6060813	749487	32.0	0.63	good	rock	Domestic/stock
GW056584	10BL123006	6060620	748155	22.9	0.37	nr	granite	Domestic
GW100156	10BL143235	6060612	748432	47.0	1.39	good	granite	Domestic/stock
GW105658	10BL156472	6060494	748645	30.0	nr	nr	granite	Domestic
GW110023	10BL165780	6060331	748872	90.0	0.19	nr	granite	Domestic
GW101854	10BL143159	6060186	748542	32.0	0.22	good	rock	Domestic/stock
GW053979	10BL136471	6060073	748971	45.7	0.05	good	granite	Domestic/stock
GW109325	10BL164918	6060885	746021	75.0	nr	nr	nr	Domestic
GW100096	10BL143635	6060630	745234	48.7	nr	nr	nr	Domestic/stock
GW102353	10BL159149	6065972	751985	6.0	nr	nr	nr	Irrigation
GW107131	10BL164683	6067285	751564	36.0	1.06	fresh	granite	Domestic/stock
GW069046	-	6067304	753712	62.0	0.42	good	granite	Domestic/stock

Note: nr = not recorded
co-ordinate projection MGA 94, Zone 56

10.2 GROUNDWATER QUALITY AND ENVIRONMENTAL VALUE

10.2.1 Terminology

An assessment was made of the groundwater quality in terms of Australia New Zealand Environment Conservation Council (ANZECC) criteria and environmental value. The ANZECC (2000)[5] guideline refers to “environmental value” rather than “beneficial use” which is often used, and state that the term beneficial use has lost favour because of its exploitative connotations. For this reason the term “environmental value” has been adopted by the National Water Quality Management Strategy (NWQMS). The following environmental values are recognised in the NWQMS Guidelines:

- aquatic ecosystems;
- primary industries (irrigation and general water uses, stock drinking water, aquaculture and human consumption of aquatic foods);
- recreation and aesthetics;
- drinking water;
- industrial water; and
- cultural and spiritual values.

The guidelines state that “where two or more agreed environmental values are defined for a water body, the more conservative of the associated guidelines should prevail and become the water quality objective”. The assessment of “environmental value” given in this report is based on this guideline.

10.2.2 Groundwater Quality

10.2.2.1 Overview

The results of analyses of water samples collected from the monitoring bores, from the spring on Spring Creek and from Dargues Shaft (**Drawing No. 4**) are given in **Table 5** and are compared with the ANZECC (2000)5 guidelines for aquatic ecosystems associated with upland rivers in south-east Australia. The metals analyses are compared with the ANZECC (2000)5 guidelines for aquatic ecosystems (freshwater species), with trigger values for 95% protection.

10.2.2.2 Granodiorite and Regolith Aquifer

Groundwater quality of the fractured granodiorite was measured from two of the installed monitoring bores and from the Dargues Reef Shaft. The table indicates that the Electrical Conductivity (EC) is quite variable ranging from 530µS/cm in DRWB01 to 4300µS/cm in DRWB03, with the water quality from the Dargues Reef Shaft being 1260µS/cm. It should however be noted that the water quality in bore DRWB03 may be anomalous as the EC was decreasing as more water was bailed from the bore, however a stabilized EC was not reached before collecting the sample as the bore took 2-3 days to recover each time it was bailed dry.

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[5] Australian and New Zealand Environment and Conservation Council, (2000), *“Australia and New Zealand Guidelines for Fresh and Marine Water Quality”.* National Water Quality Management Strategy, Chapt. 3 Aquatic Ecosystems.

The reason why the EC is high is not known as the drilling contractor only used air for drilling the hole. Therefore if DRWB03 is excluded, the EC of the fractured granodiorite probably lies in the range 530µS/cm to 1250µS/cm.

Table 5
Summary Groundwater Quality Data

Sample ID		DRWB 01	DRWB 02	DRWB 03	DRWB 04	DRWB 07	DRWB 08	Spring 1	Dargues Shaft	ANZECC (2000)
Sample Date		22/04/10	22/04/10	21/04/10	22/04/10	22/04/10	22/04/10	22/04/10	21/12/09	
Aquifer	Unit	grano-diorite	regolith	grano-diorite	regolith	alluvium	alluvium	regolith	grano-diorite	
pH value	pH	8.2	7.3	12.2	7.0	7.0	7.6	7.4	7.11	6.5 – 7.5
Electrical Conductivity	µS/cm	530	1300	4300	360	630	410	270	1260	30 - 350
Bicarbonate Alkalinity as $CaCO_3$	mg/L	199	133	<0.1	70.7	127	123	79.1		
Carbonate Alkalinity as $CaCO_3$	mg/L	<0.1	<0.1	187	<0.1	<0.1	<0.1	<0.1		
Hydroxide Alkalinity as $CaCO_3$	mg/L	<0.1	<0.1	654	<0.1	<0.1	<0.1	<0.1		
Total Alkalinity as $CaCO_3$	mg/L	199	133	841	71	127	123	79	516	
Chloride	mg/L	44	300	48	51	57	32	22		
Sulphate	mg/L	15	35	50	14	110	37	10		
Calcium	mg/L	54	110	150	26	56	42	17		
Magnesium	mg/L	14	48	<0.05	10	24	7.3	6.5		
Sodium	mg/L	34	58	310	22	31	24	23		
Potassium	mg/L	1.3	1.8	14	0.6	1.4	1.1	0.3		
Nitrate as N	mg/L	0.14	3.2	1.3	2.1	<0.01	<0.01	2.8		0.7
Nitrite as N	mg/L	0.02	<0.01	0.03	<0.01	<0.01	<0.01	<0.01		
Total Oxidized Nit. as N	mg/L	0.16	3.2	1.3	2.1	<0.01	<0.01	2.8		
Total Phosphorus as P	mg/L	0.16	0.71	0.21	0.06	0.27	0.41	0.14		0.02
Arsenic	mg/L	0.001	<0.001	0.0055	<0.001	0.002	<0.001	<0.001	<0.001	0.013
Cadmium	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0001	0.00002
Chromium	mg/L	<0.001	<0.001	0.039	<0.001	<0.001	<0.001	<0.001	<0.001	0.0001
Copper	mg/L	0.0006	0.0007	0.0011	<0.0005	0.0007	0.0005	<0.0005	0.005	0.0014
Lead	mg/L	0.0012	<0.00005	0.00019	0.00006	<0.00005	<0.00005	<0.00005	0.002	0.0034
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0006
Nickel	mg/L	0.002	0.003	0.004	<0.001	0.002	0.003	<0.001	<0.001	0.011
Zinc	mg/L	0.012	0.006	0.006	0.014	0.12	<0.005	<0.005	0.054	0.008
Note: shaded cells = exceedance of the ANZECC guidelines										

The EC of the shallow regolith groundwater varies from 360µS/cm at DRWB04 above the spring on Spring Creek to 1300µS/cm at DRWB02. The EC of the spring was 260µS/cm which probably reflects some dilution from surface runoff. Therefore based on the two bore samples the regolith has a similar EC range to that of the granodiorite; 360µS/cm to 1300µS/cm.

The pH of both the regolith and granodiorite is neutral to slightly alkaline, generally in the range pH 7.0 – 8.2, however the deep granodiorite bore DRWB03 is similarly anomalous with a highly alkaline pH of 12.2.

Nitrate as N and total Phosphorus exceed the ANZECC 2000 guideline trigger value for 95% protection of upland rivers in all samples, and this is probably related to the agricultural use of fertilizers for pasture grasses.

The metal concentrations are all below the trigger values for 95% protection with the exception of zinc in some bores, as shown on **Table 5**.

10.2.2.3 Alluvial Aquifer

The EC of groundwater collected from the alluvium and immediate underlying regolith at the base of Majors Creek varied between 410µs/cm to 630µS/cm, possibly reflecting dilution of the baseflow discharge from the granodiorite/regolith aquifers by surface runoff. The pH is slightly alkaline in the range pH 7.0-7.6. Nitrates are below ANZECC (2000) trigger values but total phosphorus concentrations of 0.27mg/L and 0.41mg/L in monitoring bores DRWB07 and DRWB08 respectively, significantly exceed the trigger value of 0.02mg/L.

The metal concentrations are below ANZECC trigger levels again with the exception of zinc which exceeds the trigger value in one of two samples.

10.2.3 Environmental Value

The water quality data indicates that the groundwater in the alluvial aquifer is suitable for human consumption due to an EC of less than 630µS/cm, that is a total dissolved salt (TDS) concentration of less than about 420mg/L. In contrast the TDS of the groundwater in the granodiorite and regolith is generally above the accepted cut off for potable water of 500mg/L and is primarily used for stock watering. However, the NOW database and the bore census indicates that groundwater in the area is used for both domestic purposes as well as for stock watering. Therefore the environmental value of groundwater of the alluvial, regolith and granodiorite aquifers has been classified as “primary industry”, and to a lesser extent “drinking water”. The environmental along Majors and Spring Creeks where there is permanent flow from groundwater discharge could be classified as “aquatic ecosystems”.

11. MINE DEVELOPMENT ANDOPERATIONAL WATER REQUIREMENTS

11.1 PROPOSED MINING METHOD AND MINE INFRASTRUCTURE

It is proposed that mining of Dargues Reef will be undertaken using an underground mining method with a permanent crown pillar left between the surface and underground working that will minimize the risk of subsidence. Access to the mine will be gained by a box-cut, development of a portal in competent rock and development of a 1 in 7 decline with sub-levels at 25m floor to floor intervals. The mine will be about 500m deep.

Mining of the ore will be achieved using sub-level, open stoping mining, with each sub-vertical stope being mined as a series of panels. Once sections of underground mining have been completed, mined out stopes will be backfilled using waste rock material with sections of some stopes being cement stabilized.

Surface facilities will include:

- a processing plant that includes ROM storage, workshop etc;

- tailings storage facility approximately 9.3ha in area;
- a temporary waste rock emplacement area.

The surface facilities are shown on **Figure 7**.

11.2 MINING RATE

The mine will have a life span of five years with a planned depth of about 500m. The decline development and volume of rock mined by year is summarized in **Table 6.**

Table 6
Indicative Mining Rate / Mine Development

Year	Tonnage Mined (Ore & Waste) (tonnes)	Decline Level (RLm)
0	-	~670
1	326,750	400
2	360,000	169
3	494,250	169
4	371,750	169
5	108,500	169

The decline will reach total depth by the end of Year 2 and will be followed by sub-level open stoping mining. The mine design and method are illustrated on **Figure 8**.

11.3 OPERATIONAL WATER SUPPLY

11.3.1 Water Requirements

Maximum operational water requirements for mineral processing, dust suppression, underground mining and workshop wash-down purposes have been estimated to be approximately 885ML/year. Of this approximately 755ML/y can be reclaimed from the tailings storage facility. Therefore approximately 130ML/y of make-up water will be required as a maximum. This water will be sourced from the Proponent's harvestable right and groundwater.

In a separate study undertaken for this Project by Strategic Environmental and Engineering Consulting (SEEC, 2010 - presented as Part 4 of this *Specialist Consultant Studies Compendium)*, modelling of surface water availability from the Proponent's harvestable right indicate that dewatering of the Dargues Reef Mine and extraction of water from the proposed harvestable rights dams could supply the entire water requirements for the operation 85% of the time. The remaining water required for operational purposes, will be required to be sourced from groundwater. Potential groundwater sources include the following.

- Dewatering of the Dargues Reef Mine, both existing workings and those proposed by the Proponent;

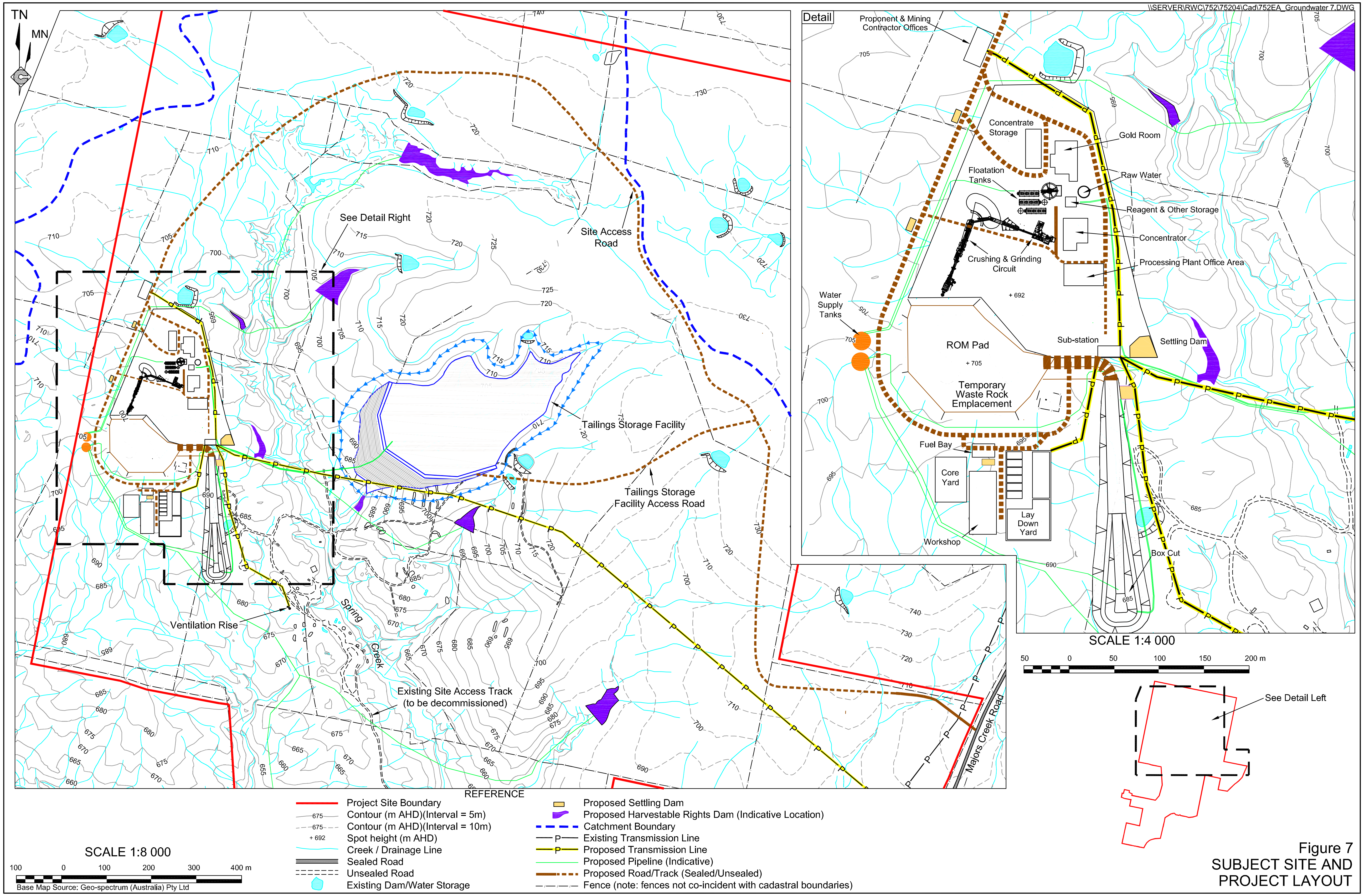
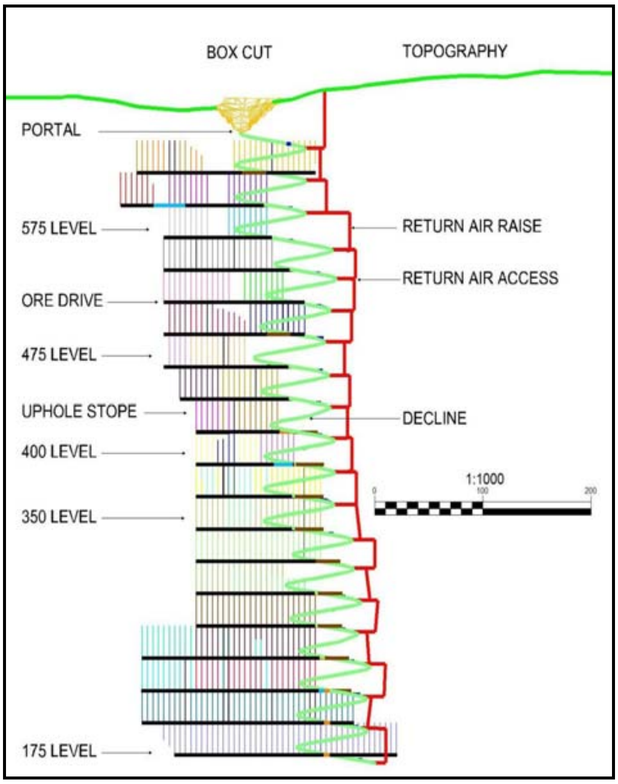
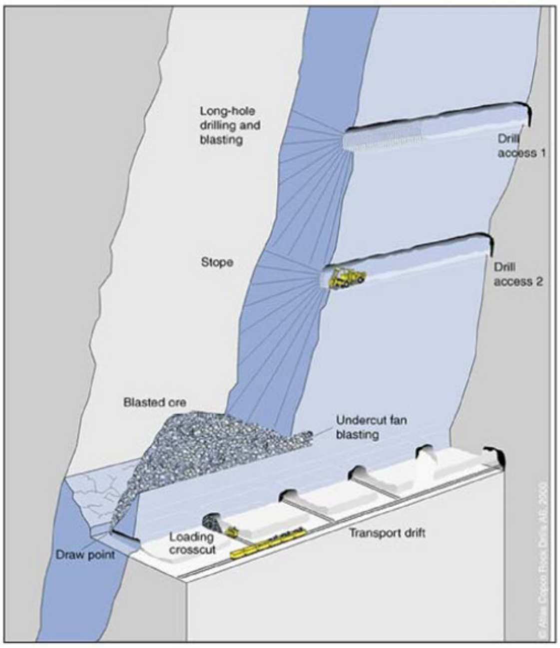


Figure 7
SUBJECT SITE AND PROJECT LAYOUT

- Dewatering of groundwater stored in flooded workings in the southern sector of the Project Site, that is the shafts and stopes of the former Snobs, Stewart and Mertons and United Miners mines (**Drawing No. 2**);
- Extraction from dedicated water supply bores.





Figures from:
Conceptual Project Development Plan (Dec 2009) – left
Preliminary Environmental Assessment (Mar 2010) - above

**Figure 8: Longitudinal Projection of Proposed Mine (left)
Schematic Sublevel Open Stoping Mining Method (right)**

As discussed NOW have advised that the embargo on the alluvial aquifers and surface water in the vicinity of the Project Site does not apply to the fractured rock system or regolith, or to obtaining water from the old mine workings *"as long as no alluvial groundwater is intercepted in the process".*

11.3.2 Flooded Historic Workings

The Proponent provided volumes of the stoped area for Snobs, Stewart and Mertons and United Miners workings which were worked between 1850 and 1939 and which are currently flooded. The stope shapes and volumes are based on historic plans which show that Stewart and Mertons and United Miners are interconnected. A summary of the void volumes of each mine based on the mine plans is presented in **Table 7**. **Table 7** indicates that the total void volume of the old mines is about 82,000m^3. However, in order to obtain a conservative estimate of the volume of recoverable water for operational purposes, the void volumes have been discounted by 60%. This allows for:

- the groundwater level being up to 30m below surface, meaning that the top section of the voids are not flooded, and
- not all water would be recoverable.

The estimated recoverable water stored in the shafts is therefore about 50ML.

Table 7
Summary of Old Mine Data

Mine	**Shaft Location**		**Shaft Elevation (RLm)**		**Depth**	**SWL**	**Void Volume**	**Est. Recoverable Water**
	(mE)	**(mN)**	**Surface**	**Bottom**	**(m)**	**(RLm)**	**(m3)**	**(mL)**
Snobs	748081	6062070	695.7	543.9	151.8	665	38,100	23
Stewart & Mertons	748415	6061916	674.7	590.5	84.2	645	17,160	10
United Miners	748534	6061878	661.2	533.5	127.7	645	26,900	16
TOTALS							82,160	49

Note: i) SWL = static water level

A section through of the historic mine workings is shown on **Figure 9**.

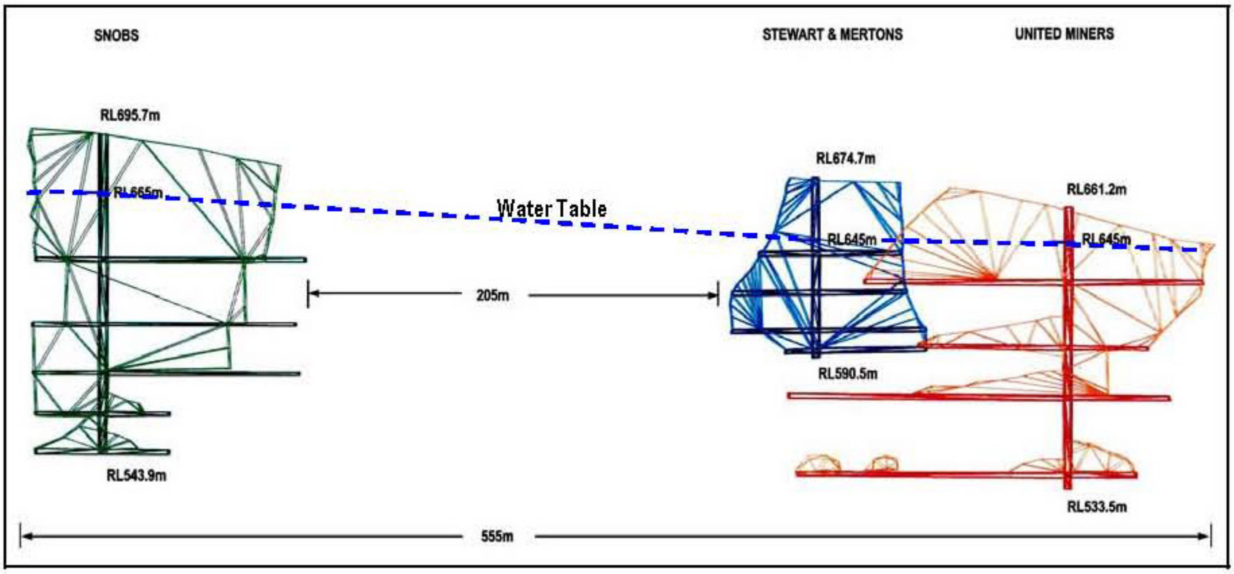


Figure 9 West – East Section through the Historic Workings

12. NUMERICAL GROUNDWATER MODEL

12.1 MODELLING OBJECTIVES

Predictive numerical modelling was undertaken to assess the impact of the proposed Dargues Reef Gold Project on the groundwater regime. The objectives of the predictive modelling were to:

- assess groundwater inflow to the mine as a function of mine position and timing;
- assess groundwater inflow to the old mine workings and the volume and sustainability of a make-up supply from this source;
- simulate and predict the area of influence of mine dewatering and mine water supply, and the level of drawdown at specific locations;
- predict the impact of mine dewatering and mine water supply on the alluvial aquifer;

- predict the impact of mine dewatering on other groundwater users, both human and groundwater dependent ecosystems (GDEs); and
- identify areas of potential risk where groundwater impact mitigation/control measures may be necessary.

12.2 CONCEPTUAL MODEL

Key to the success of the modelling exercise is the adequate conceptualisation of the aquifer system. The conceptualisation needs to account for the model objectives to ensure the resulting model is “fit for purpose”.

The conceptual model is the basic idea of how the groundwater system operates given the available data, and is an idealised and simplified representation of the natural system. It includes all essential features of the system, that is, the hydrogeological regime as described in Section 9.0, to an appropriate level of detail. Extensive information on the natural system is typically required to develop an equivalent and simplified conceptual groundwater model representative of the system. Formulation of the conceptual model often highlights gaps in data or deficiencies in understanding of the groundwater system.

“A conceptual model contains numerous qualitative and subjective interpretations. The appropriateness of the conceptual model cannot be tested until a numerical model is built and comparisons between field observations and model simulation results are made” (Zheng and Bennett [1995])[6].

The conceptual groundwater model of the Project Site, illustrated on **Figure 10**, was developed from the description of the hydrogeological regime as given in previous sections.

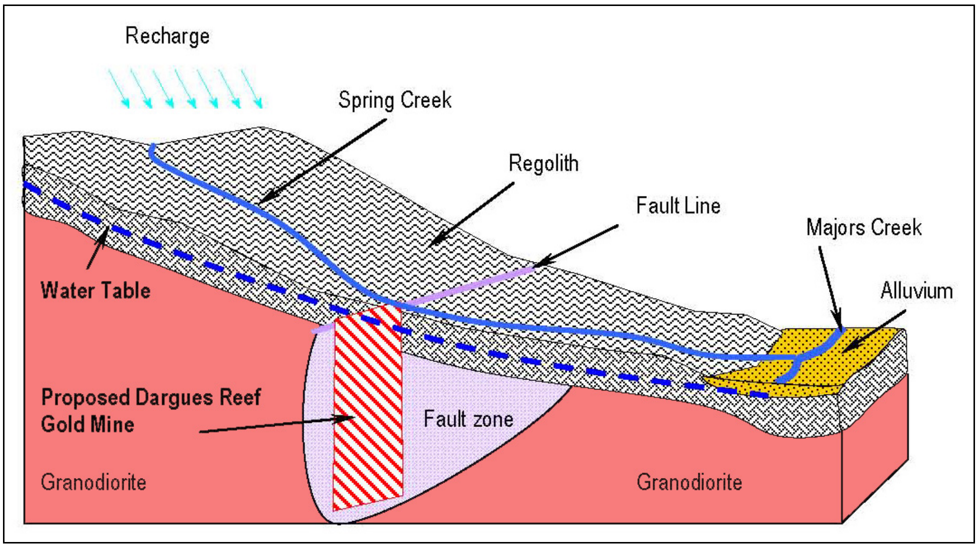


Figure 10 Conceptual Model of Groundwater Regime

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[6] Zheng C. and Bennett G., (1995), *“Applied Contaminant Transport Modelling”*. Wiley, New York.

The conceptual model of the region encompasses the area of the granodiorite subcrop and a veneer up to 15m thick of weathered granodiorite; the regolith. Thin Quaternary alluvium is associated with the Majors Creek whereas thin colluvial deposits and regolith form the base of Spring Creek and other tributary creeks.

The conceptual model therefore includes the three aquifer systems:

- the granodiorite or fractured rock aquifer system;
- the shallow weathered rock (regolith) aquifer; and
- a localized aquifer system associated with the alluvial deposits of Majors Creek.

Recharge of the regolith aquifer and the alluvium occurs from rainfall infiltration whereas recharge of the granodiorite occurs by direct infiltration of rainfall in outcrop area and through seepage from the regolith. Similarly recharge of the alluvium occurs by direct infiltration of rainfall, discharge from the regolith and granodiorite aquifers and some runoff from the creeks side slopes. Some discharge from the aquifers may also occur through evapotranspiration where deep rooted remnants of the native vegetation remain.

12.3 MODEL DEVELOPMENT

12.3.1 Model Code

Decisions on the modelling code were made in conjunction with the formulation of the modelling approach discussed in Section 12.3.2. Numerical simulation of groundwater flows in the aquifers for the Project Site was undertaken using the MODFLOW SURFACT code (referred to as SURFACT for the remainder of the report). A commercial derivative of the standard MODFLOW code, SURFACT is distributed by HGL[7] and has some distinct advantages over MODFLOW; advantages that are critical for the simulation of groundwater flow at the Project Site.

The MODFLOW code (on which SURFACT is based) is the most widely used code for groundwater modelling and is presently considered an industry standard. Use of the SURFACT modelling package is becoming increasingly widespread, particularly in mining applications where groundwater dewatering and recovery are simulated.

First and foremost, SURFACT is capable of simulating unsaturated conditions. This is critical for the requirements of the proposed Dargues Reef Gold Mine where the fractured granodiorite will progressively be dewatered with time until the end of mining when active dewatering will cease and groundwater recovery will rewet the drained fractures. SURFACT is also supplied with more robust numerical solution schemes to handle the more complex numerical problem resulting from the unsaturated flow formulation. Added to the more robust numerical solution schemes is an adaptive time-stepping function that aides the progression of the solution past difficult and complex numerical situations such as oscillations.

The MODFLOW pre- and post processor PMWIN (Chaing and Kinzelbach, 1996)[8] was utilised to generate some of the input files for the SURFACT model, such is the similarity between it and the standard MODFLOW. Where files differ to allow for the additional capabilities of SURFACT, these changes were undertaken through manual editing of the model files.

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[7] Hydrogeologic Inc., MODFLOW SURFACT Software (Version 3.0), Herdon, VA, USA.

[8] Chaing W.H. and Kinzelbach W., (1996), *"Processing MODFLOW for Windows".*

12.3.2 Modelling Approach

The methodology for predicting the inflows into the Dargues Reef Gold Mine and to the old mine shafts, if they are used for a make-up water supply, involves the construction and calibration of an appropriate groundwater model, and then using that model to predict changes to the groundwater regime resulting from the activities.

The conceptual mining schedule received from the Proponent equates to 5 years of mining to a depth of about 500m below surface as discussed in Section 11.2. Although the mined stopes would be progressively backfilled with waste rock with some sections being cement stabilized, it was assumed for modelling purposes that the permeability of the stopes was sufficiently high compared to the in-situ rock mass to allow the whole of the mine to be simulated as an open void. That is, progressive parameter adjustments; changes to hydraulic conductivity to represent the mined stopes and zones of enhanced hydraulic conductivity caused by the waste rock emplacement were not made as the stopes were backfilled.

Mine dewatering is simulated in SURFACT through the drain (DRN) package. This involves the setting of a reference elevation and a conductance term. Groundwater levels in the model are compared to the reference elevation in each cell and when the groundwater level is above the reference level water is removed from the model domain at a rate determined by the head difference and the conductance. In the case of Project, the drain cells used to simulate dewatering are set to a reference level determined by the progressive rate of mine development, that is, the rate at which the depth of the mine increases. A nominally high drain conductance rate (~1000m^2/d) is used to facilitate free drainage conditions from the strata and ensure the groundwater level is lowered to the reference level, hence dewatering the mine to that level.

12.3.3 Model Geometry

The model domain was discretised into rectangular cells arranged into 7 layers comprising 221 columns and 184 rows. There are 40,664 active cells in each layer with the dimensions of the cells varying approximately from 12.5m by 12.5m within the mining area and area of the old mines, up to 100m by 120m at the extremities of the model, as shown on **Drawing No. 6**. The model extent varies from about 7km from west to east and is about 6km from north to south, covering an area of approximately 42km^2.

The model grid was rotated by 30 degrees at the north-west corner (744159mE and 6063540mN) in order to align it with the north-westerly major drainage lines and south-easterly direction of groundwater flow in the shallow aquifer.

The thirty-metre grid Digital Elevation Model data downloaded from **ASTER Global DEM data** (wist.echo.nasa.gov) was used to interpolate the surface elevation and hence surface of the model. The elevation of the surface of the model area ranges from 465m AHD in the south-east to 780m AHD in the north-east.

The model consists of seven model layers in total representing the three groundwater bearing units. Layer 1 represents localized alluvial deposits and weathered bedrock, with a thickness varying from 1m to 3m. Layer 2 represents the weathered bedrock (regolith) with the base being 15m below ground level. Layers 3 to 7 have the same hydraulic properties and represent the granodiorite. The bottom elevation of Layers 3 to 7 are respectively 50m, 100m, 200m, 300m and 600m below the ground surface. The base of the model was set at 600m below ground level. The model layers are shown on **Figure 11**.

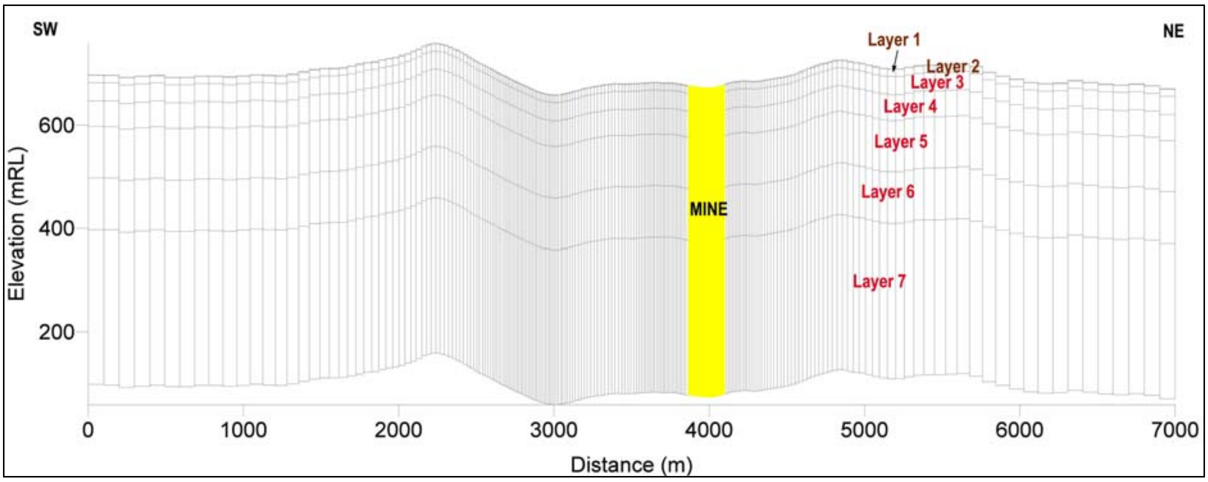

Figure 11 Model Layers

As discussed the faults and lineaments shown on **Drawing No. 3**, which were mapped or interpreted by the Proponent are zones of weakness and appear to control drainage patterns within the Project Site and surrounds. They are also groundwater bearing zones as indicated by anecdotal information that where intercepted by exploration drill holes, the holes yield water. The faults and lineaments are represented in the model as zones with higher hydraulic conductivity values from the surrounding strata. As there is a large of number of faults and there is little data to enable the hydraulic characteristics of each individual fault to be characterized, all fault zones were assumed to have the same hydraulic conductivity value.

12.3.4 Boundary Conditions

Water entering or leaving the model domain is simulated through the actions of boundary conditions. The specific boundary flows and their representation in the model are discussed below.

No Flow Boundaries

The model area consists predominantly of granodiorite and weathered granodiorite (regolith) which typically have a low hydraulic conductivity. Therefore, groundwater flow in pristine conditions is likely controlled by topography, that is, the groundwater divide is coincident with the surface water divide. The model is large enough to cover the catchments within the Project area draining to Majors Creek and the boundaries are far enough from the mine site so that the modelling results are unlikely to be affected by the boundary. The model boundaries on all four sides and the base of the model were assigned as no flow boundaries. A “no flow” boundary does not allow any exchange of water between the model domain and the surrounding areas.

Recharge

Recharge of the regolith and alluvial aquifers was modelled using SURFACT's RCH Package where recharge enters the model domain through injection wells located at the centre of the assigned cells. Recharge to the regolith and alluvium from rainfall was applied to Layer 1 of the model domain. The rate of recharge to the aquifers was not known and was therefore obtained during model calibration as is described in detail in Section 12.4.3.

Discharge

In pristine conditions, groundwater discharges into the creeks. This process was simulated using SURFACT "drain" cells. The drain elevation was taken from the Digital Elevation Model (DEM) and set at the surface elevation along the drainage lines. A nominally high drain conductance of 1,000m^2/day was applied to the drain cells.

As discussed, dewatering of the Dargues Reef Mine during the mining operations was also simulated using drain cells with a progressive decrease in drain cell elevation corresponding to the mining progress.

The pumping from the old workings to augment the operational make-up water requirements was simulated using the Fractured Well package of SURFACT using an equivalent well diameter of 12m, which takes into account the storage of the old workings.

12.4 STEADY STATE MODEL CALIBRATION

12.4.1 Overview

*"Calibration of a groundwater flow model refers to a demonstration that the model is capable of producing field measured heads and flows, which are the calibration values. Calibration is accomplished by finding a set of parameters, boundary conditions and stresses that produce simulated heads and fluxes that match field measured values within an acceptable range of error" (*Anderson and Woessner [1992])[9].

The objective of model calibration was to reproduce measured groundwater levels in Layer 1 and construct the starting head water levels for the regolith and granodiorite (Layers 2 to 7). The accuracy of the model calibration depends on the quality of calibration parameters, and the data defining the model domain such as aquifer geometry, boundaries, hydraulic properties and stresses imposed on the aquifer. It is considered that the horizontal and vertical extent of the model and model boundaries are sufficiently well defined to construct and calibrate the Dargues Reef groundwater model.

Calibration of the model was achieved using the PEST software[10] and associated utilities. Where model parameters and/or excitations need to be adjusted until model-generated numbers fit a set of observations as closely as possible then, provided certain continuity conditions are met, PEST (an acronym for Parameter ESTimation) will adjust model parameters and/or excitations until the fit between model outputs and laboratory or field observations is optimized in the weighted least squares sense.

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[9] Anderson & Woessner (1992), *"Applied Groundwater Modelling, Simulation of Flow and Advective Transport".*

[10] Doherty, J., (1996), *"PEST Model Independent Parameter Estimation"* Watermark Numerical Computing, Brisbane.

12.4.2 Calibration Targets

Groundwater level measurements from thirty five (35) open exploration holes within the Project area and from the seven (7) monitoring bores were used as observation data for the calibration of the model. The water levels in the open exploration holes were measured in February 2010 and check levels were made in late April 2010 at which time water levels from the monitoring bores were also measured. Most exploration holes are angle holes and the measured water level was corrected to vertical depth, as shown in **Appendix 5**. The location and elevation of the collar of all exploration holes and monitoring bores had been surveyed, and therefore the groundwater levels were considered accurate and reliable observations against which to calibrate.

Long term monitoring had not been undertaken and therefore the calibration was performed as a steady state calibration without any impact from mining. The recharge rate was varied within an acceptable range and PEST was then run until the closest match between model predicted water levels and field measured water levels was reached and acceptable hydraulic parameters obtained.

A total of 42 water level data were used for calibration. Due to a lack of long term monitoring data it was assumed that the water levels in the bores selected for steady state calibration were representative of the long term average (steady state) groundwater levels. However, fluctuations in groundwater level in the area are expected. A summary of the bores used in the calibration process, comparison of observed and simulated groundwater levels in the Dargues Reef model area and the difference between levels is presented in **Table 8**. A scattergram with observed and calculated water levels is shown on **Figure 12**.

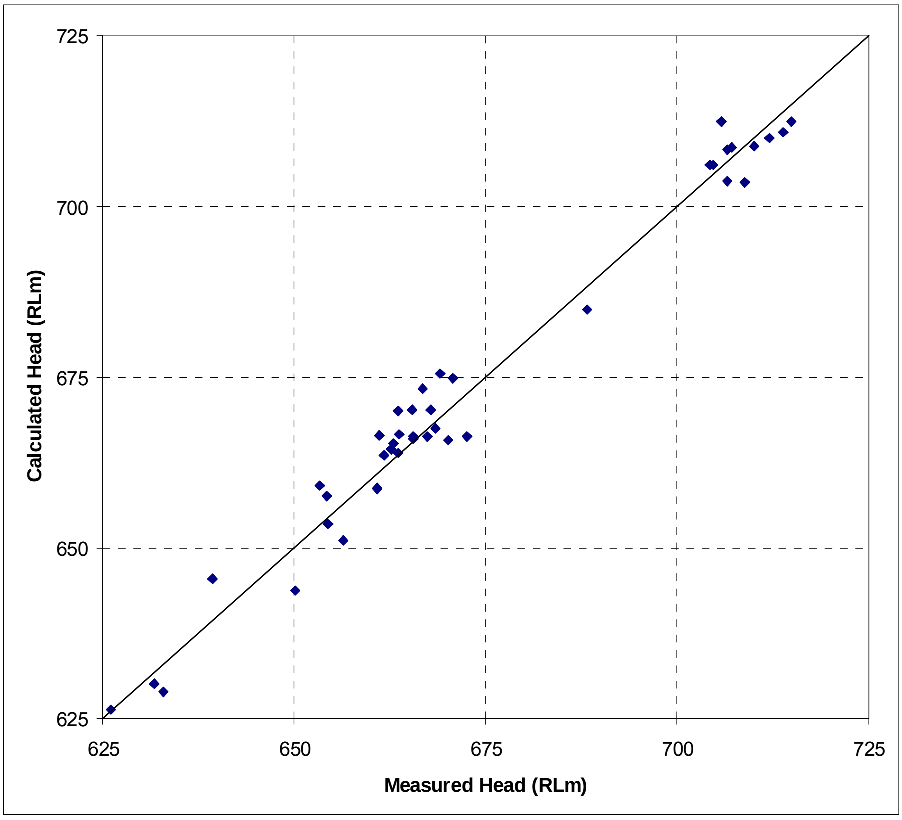

Figure 12 Scatter Diagram: Calibrated versus Observed Groundwater Levels

Table 8
Calibration Targets and Simulated Water Levels

Bore ID	Location		Water Level (mAHD)		Difference (m)
	(mE)	(mN)	Observed	Simulated	
DREX119	749228.3	6062886.2	667.8	670.286	-2.5
DREX124	749467.0	6062937.8	688.3	684.865	3.4
DREX130	748803.7	6062890.3	670.8	674.798	-4.0
DREX146	749000.9	6062601.9	654.3	657.542	-3.2
DREX147	748929.1	6062670.7	653.3	659.208	-5.9
DREX154	748905.5	6062838.5	662.7	664.384	-1.7
DREX155	748859.5	6062899.7	663.5	670.034	-6.5
DREX161	748913.0	6062894.1	665.6	665.925	-0.3
DREX170	748895.8	6062963.7	669.1	675.565	-6.5
DREX174	748943.5	6062862.7	662.9	665.323	-2.4
DREX175	748944.1	6062909.4	663.7	666.618	-2.9
DREX180	748977.0	6062904.0	661.1	666.424	-5.3
DREX184	749013.0	6062963.0	666.7	673.244	-6.5
DREX37	749139.5	6062828.1	665.6	666.249	-0.6
DREX58	749154.4	6062926.9	665.4	670.251	-4.9
MCDD032	749788.8	6061857.6	656.4	651.118	5.3
MCRC001	749411.7	6063772.2	712	709.904	2.1
MCRC002	749311.8	6063749.1	707.1	708.544	-1.4
MCRC003	749514.1	6063863.4	714.9	712.413	2.5
MCRC005	749987.0	6063714.2	713.9	710.896	3.0
MCRC007	750114.4	6063574.6	706.5	708.344	-1.8
MCRC009	749684.4	6063392.6	706.6	703.713	2.9
MCRC010	749698.6	6063375.1	708.9	703.48	5.4
MCRC011	749506.7	6063674.9	710.1	708.782	1.3
MCRC015	749775.1	6061918.9	654.4	653.432	1.0
MCRC018	749654.3	6061822.7	639.3	645.488	-6.2
MCRC019	748215.8	6062053.9	660.8	658.692	2.1
MCRC020	748214.6	6062067.3	660.8	658.833	2.0
MCRC022	748137.8	6062103.2	663.6	663.899	-0.3
MCRC023	748153.8	6062128.6	661.8	663.489	-1.7
MCRC024	748116.2	6062134.0	670.1	665.72	4.4
MCRC025	748114.8	6062131.0	667.4	666.266	1.1
MCRC026	748110.1	6062115.1	672.6	666.213	6.4
MCRC027	748476.1	6061998.2	650.2	643.835	6.4
MCRC030	748045.9	6061985.8	668.4	667.471	0.9
DRWB01	748681.1	6063944.8	705.8	712.398	-6.6
DRWB02	748676.6	6063945.8	705.8	712.398	-6.6
DRWB03	749111.8	6063817.2	704.3	706.117	-1.8
DRWB04	749115.8	6063814.4	704.7	706.117	-1.4
DRWB06	748848.7	6061994.6	631.7	630.057	1.6
DRWB07	748724.7	6061835.4	632.9	628.899	4.0
DRWB08	749240.0	6061796.4	626.1	626.401	-0.3

Note: highlighted bores are monitoring bores installed by the Project - the remainder are open exploration holes.

12.4.3 Calibration Acceptance

An objective method to evaluate the calibration of the model is to examine the statistical parameters associated with the calibration. One such method is by measurement of the error between the modelled and observed (measured) water levels. A root mean square (RMS) is considered to be the best measure of error, if errors are normally distributed. The RMS is expressed as:

$$RMS = \left[1/n\,\Sigma(h_o - h_m)_i^2\right]^{0.5}$$

where: n = number of measurements
h_o = Observed water level
h_m = Simulated water level

The RMS error calculated for the calibrated model is 3.9m.

The maximum acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error to the total head loss in the system is small, the errors are only a small part of the overall model response, (Anderson and Woessner)9. The total observed head loss within the model domain is 88.8m; therefore the ratio of RMS to the total head loss is 4.4%. Considering the heterogeneous characteristics of a fractured rock aquifer, this calibration error is considered to be acceptable.

12.4.4 Calibrated Recharge

The rate of recharge was adjusted to achieve calibration using PEST. The recharge values that provided an acceptable calibration were 45mm/year (6.3% of the annual rainfall) to the areas associated with the upper flatter slopes and hill tops, 20mm/year (2.8% of the annual rainfall) to the steeper side slopes and 3mm/year (0.5% of the annual rainfall) to the low lying and thin alluvial areas adjacent to Majors Creek, that is the groundwater discharge zone. Recharge was applied uniformly throughout the year to correspond with the fairly evenly distribution of rainfall pattern.

12.4.5 Calibrated Hydraulic Parameters

As discussed the hydraulic conductivity of the aquifers and of the faults was calibrated using PEST. The hydraulic parameters of the model domain which resulted in the best calibration fit and which fall into what is considered an acceptable range for the aquifers, based on the falling head tests, records of groundwater yield and literature research, are as shown in **Table 9**.

The calibrated hydraulic conductivity of the alluvium is 2.72m/day. This is higher than that obtained from falling head tests of bores established in the bed of Majors Creek which gave a hydraulic conductivity of 5 x 10^{-2}m/day. However the material tested in the bed of Majors Creek has been reworked by gold mining and has lost its primary porosity. In addition, as the alluvium is quite thin, part of the bore screens are against the upper part of the underlying regolith and therefore the hydraulic conductivity obtained from the falling head test is a composite of the alluvium and regolith. The falling head tests were therefore undertaken on material that would be expected to have a low hydraulic conductivity, not representative of undisturbed alluvium.

The calibrated hydraulic conductivity of the regolith of 1.59 x 10^{-1}m/day matches reasonably well the hydraulic conductivity range obtained from the falling head tests of 2.02 x 10^{-2}m/day to 1.31 x 10^{-1}m/day. Similarly the calibrated hydraulic conductivity of the granodiorite of 3.78 x 10^{-5}m/day matches quite well the hydraulic conductivity range obtained from the falling head tests of 8.69 x 10^{-5}m/day to 4.68 x 10^{-4}m/day.

Field testing of the hydraulic conductivity of the fault zones was not undertaken, however the model calibrated hydraulic conductivity of 2.92 x 10^{-3}m/day for faults in the weathered zone and 1.92 x 10^{-3}m/day for faults in fresh rock are considered acceptable based on anecdotal data that exploration holes that intercept fractured rock provided reasonable yields of groundwater compared to those that did not intercept fractures.

Table 9
Hydraulic Parameters

Layer	Parameter	Value
Layer 1 (Alluvium / Colluvium)	Horizontal Hydraulic Conductivity (kh)	2.72 m/day
	Vertical Hydraulic Conductivity (kv)	2.72 m/day
	Specific Yield (Sy)	0.05
	Specific Storage (Ss)	1 x 10^{-5}
Layer 2 (Regolith)	Horizontal Hydraulic Conductivity (kh)	1.59 x 10^{-1} m/day
	Vertical Hydraulic Conductivity (kv)	1.59 x 10^{-1} m/day
	Specific Yield (Sy)	0.05
	Specific Storage (Ss)	1 x 10^{-5}
Layers 3 to 7 (Granodiorite)	Horizontal Hydraulic Conductivity (kh)	3.78 x 10^{-5} m/day
	Vertical Hydraulic Conductivity (kv)	3.78 x 10^{-5} m/day
	Specific Yield (Sy)	0.01 and 0.001
	Specific Storage (Ss)	1 x 10^{-5}
Faults (Regolith)	Horizontal Hydraulic Conductivity (kh)	2.92 x 10^{-3} m/day
	Vertical Hydraulic Conductivity (kv)	2.92 x 10^{-3} m/day
	Specific Yield (Sy)	0.02
	Specific Storage (Ss)	1 x 10^{-5}
Faults (Fresh Bedrock Layers)	Horizontal Hydraulic Conductivity (kh)	1.92 x 10^{-3} m/day
	Vertical Hydraulic Conductivity (kv)	1.92 x 10^{-3} m/day
	Specific Yield (Sy)	0.02
	Specific Storage (Ss)	1 x 10^{-5}

The vertical hydraulic conductivity was assumed to be the same as the horizontal hydraulic conductivity.

The calibrated hydraulic conductivity values for Layers 1 and 3 are shown on **Drawing No. 7.**

Of particular note is that there was no long term groundwater monitoring data on which to calibrate the model to transient conditions and hence to obtain calibration values for specific yield (Sy) and specific storage (Ss), that is the storativity of the aquifers. The values were therefore assumed for each aquifer based on experienced and published data. The values adopted for each aquifer unit given in **Table 9** are considered typical. Two values of specific yield, reflecting the typical range, were adopted and simulated for the granodiorite.

13. PREDICTIVE SIMULATIONS

After the steady state model was calibrated to the available data, the model was then converted to transient flow conditions to undertake the predictive scenarios.

13.1 ASSUMPTIONS

To achieve the transient simulation of mine progression, that is the advancement of the decline, the following assumptions were made.

- The decline advancement was based on plans provided by the Proponent.
- The 5 years of mining was subdivided into 60 stress periods, each of one month duration.
- Drain cells simulating dewatering of the decline and mine were activated based on the rate of decline advancement.
- Once a drain cell was activated, it remained activated until the completion of mining.
- The base case specific yield of the granodiorite is 0.001. A specific yield of 0.01 was also assumed and simulated to provide a range of inflow.

13.2 INFLOW TO DARGUES REEF MINE

SURFACT predicts groundwater heads and cell by cell flows and reports these for each specified model output time, in this case on a monthly basis. One of the key flows reported in the model budget is the amount of water that is removed from the model domain through the drain boundary condition. This boundary condition represents the dewatering of the regolith, granodiorite and fractures in the model, and thus provides a prediction of the inflow to the mine.

As discussed in Section 11.2, the mine scheduling indicates that mining will occur over a five-year period and that the decline will reach the total planned mine depth of about 500m by the end of Year 2. Inflow during development of the decline and subsequent mining was simulated in one month time steps. Due to the uncertainty of the actual value of specific yield of the granodiorite the inflow was simulated using specific yield (Sy) values of 0.001 and 0.01 which is considered a realistic range. The resultant simulated inflow to the Dargues Reef Mine is presented in **Figure 13** which for a specific yield of 0.001 indicates an initial inflow of about 7.5L/s steadily increasing as the decline descends through the regolith and into the fresh, fractured granodiorite. A maximum inflow of about 9L/s is predicted to occur at the end of Year

1, when the mine is at about RL400m, about 270m depth. Inflow remains relatively constant at around 9L/s as the decline is developed to the total depth of about 500m (RL169m), over the next 12 months. In the subsequent three years of mining inflow exponentially decreases to about 7.2L/s at the end of mine life (Year 5).

The inflow data indicates that during decline development, the higher inflows are derived from aquifer storage, but that this depletes quite rapidly, as would be expected given the storativity of the granodiorite rock mass is very low, assumed 0.001, (0.1%). Subsequent to depletion of storage the main inflow is derived from rainfall recharge to the groundwater systems.

The predictive simulation using a specific yield of 0.01 indicates that the inflow is larger during decline development to total depth, as would be expected, with a maximum inflow at the end of Year 1 of about 10.2L/s and remaining relatively constant during Year 2. However in the final 3 years of mining the inflow decreases to inflow rates very similar to those simulated for a specific yield of 0.001. Again this would be expected if the inflow during the final 3 years is derived from recharge and not storage in the rock mass.

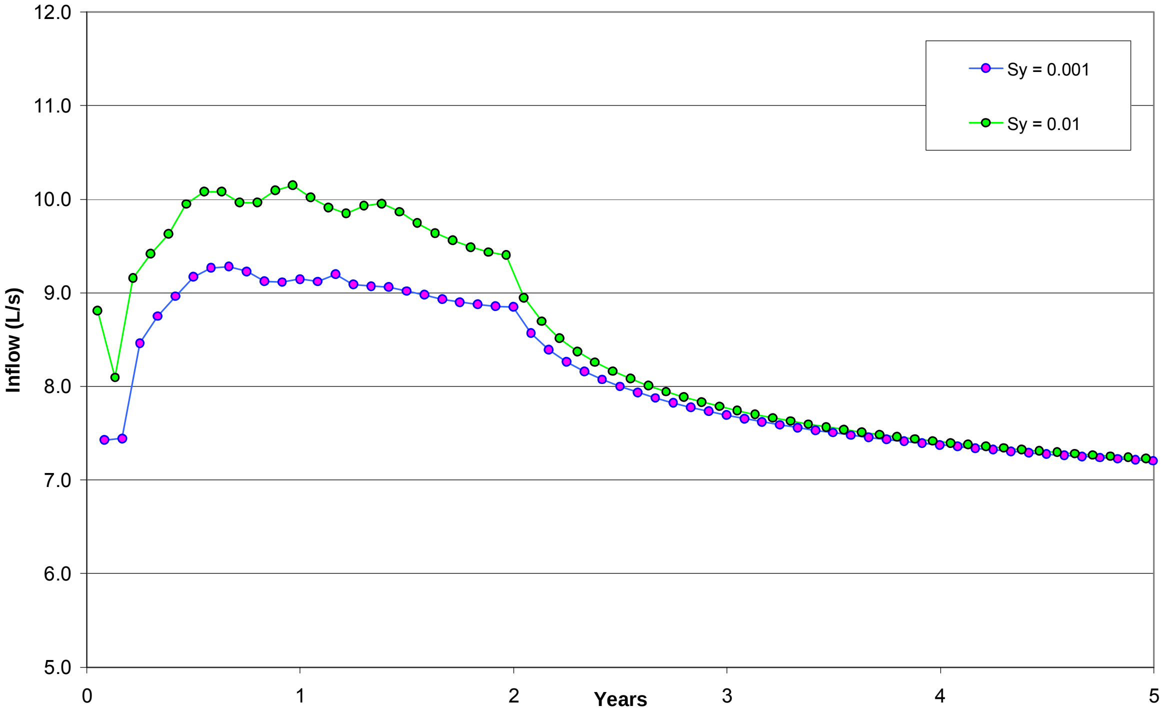

Figure 13 Predicted Inflow to Dargues Reef Mine

When assessing the predictions, it should be noted that the simulated inflows are potentially a conservative overestimate as some faults may act as barriers to groundwater flow rather than conduits. It is also important to note that a proportion of the water reporting to drain cells in the model, that is the model simulated groundwater inflow, will not report to dewatering pumps in the mine. This is because the inflow simulated by the model includes water that is removed with the ore (as moisture in the ore), and water removed as a vapour by the ventilation system. The Proponent has estimated that the maximum loss of water with the ore is about 0.6L/s and that based on a mine ventilation requirement of between 145m^3/s and 181m^3/sec, water loss through the ventilation system is between 0.14L/s and 0.18L/s. Therefore, based on the Proponent's estimates, the total maximum water loss is about 0.8L/s, and in theory the simulated groundwater inflow to the mine less this water loss, should be collected from sumps strategically located in the mine. That is between 8L/s and 9L/s should be available to augment the mine make-up water requirement during Years 1 and 2 and about 7L/s in Year 3 reducing to 6L/s at the end of Year 5.

In developing a mine water balance the potential overestimate of inflow and loss of water should be considered, and therefore it is recommended that 4L/s (126ML/year) be adopted as a conservative estimate of inflow that can collected by the dewatering pumps and used as part of the Project's water supply requirements.

13.3 GROUNDWATER SUPPLY - HISTORIC WORKINGS

As discussed in Section 11.3.1, water extracted from the proposed Dargues Reef Mine, together with the Proponent's harvestable right surface water supply is expected to be able to provide all operational water requirements 85% of the time, based on 100years of rainfall data. As a result, additional water sources will be required. An alternative, back-up source was identified in the flooded workings of the historic Snobs, Stewart and Mertons and United Miners workings (**Drawing No. 2**).

Pumping from the workings was simulated using the Fractured Well package of SURFACT. The Fractured Well package allows for storage in the workings which was simulated by specifying a 12m diameter well. The following pumping rates from each of the workings were as follows.

• Snobs Mine	1.25L/s
• Stewart and Mertons Mine	0.5L/s
• United Miners Mine	0.75L/s

In assigning the pumping rates, the size (volume) and depth of the mines were considered and importantly the distance of the mines from Majors Creek, with the objective of minimizing drawdown beneath and hence impact on the creek alluvium.

The highest pumping rate of 1.25L/s was applied to Snobs as it is relatively deep, (about 120m below the water table), has the most extensive workings, and at 600m is the furthest from Majors Creek. Stewart and Mertons is relatively shallow at about 54m depth below the water table and was assigned the smallest pumping rate of 0.5L/s. The United Miners shaft extends about 110m below the water table, its workings are less extensive than Snobs and it is adjacent to Majors Creek. Consequently it was assigned a pumping rate of 0.75L/s.

The model simulated continuous pumping from each mine shaft at the specified rates which provides for a worst case scenario as, if required, pumping from the shafts is likely to be intermittent.

The drawdown hydrographs for the shafts are shown on **Figure 14** (Snobs) and **Figure 15** (Stewart and Mertons and United Miners). There is about 70m of drawdown to 592m AHD in the Snobs working at a continuous pumping rate of 1.25L/s. This level is well above the base of the workings at 544m AHD. Similarly the simulated drawdown in the Stewart and Mertons workings at a pumping rate of 0.5L/s is 28m to 618m AHD, about 27m above the base of the workings, whereas the drawdown in United Miners workings at a pumping rate of 0.75L/s is about 23m to 622m AHD, about 88m above the base of the workings. It is considered that there is less drawdown in United Miners than Stewart and Mertons as the mine is deeper and captures groundwater inflow from a larger area. It also has greater storage than Stewart and Mertons. In reality the groundwater level in both mines would probably decline at a similar rate as old reports indicate that they are interconnected.

An average drawdown in the Stewart and Mertons and United Miners shaft to RL620m is about 12m below the bed of Majors Creek.

The model simulated pumping rates indicates that if needed, a groundwater supply of 2.5L/s (79ML/year) can potentially be obtained by pumping from the old mine shafts.

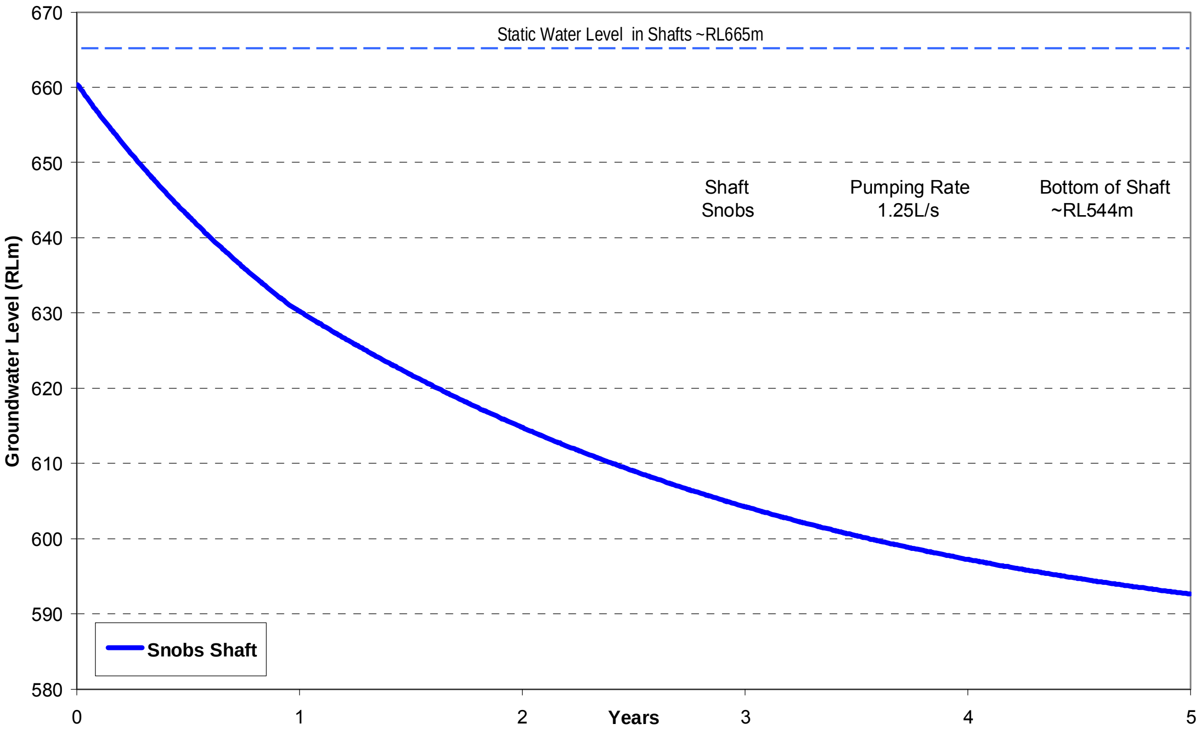

Figure 14 **Predicted Drawdown in Snobs Workings**

13.4 IMPACT ON WATER TABLE / PIEZOMETRIC SURFACE LEVELS

The impact of dewatering the Dargues Reef Mine and pumping from the historic workings on the groundwater table/ piezometric surface was simulated by the model. The water level contours and the drawdown contours at the end of mining operations, namely in Year 5, within and surrounding the Project Site are shown on **Drawing Nos. 8** and **9** respectively. The drawdown is the difference between the pre-mining groundwater levels and the levels at the end of the Year 5 mining period. **Drawing No. 9** indicates that the radius of influence, as indicated by the 1m drawdown contour, extends up to 2.5km from the Dargues Reef mine. The 1m drawdown contour is taken as the maximum radius of measurable impact, as groundwater levels are likely to naturally fluctuate by more than 1m. The drawdown pattern is asymmetrical and is heavily influenced by the faults as is clearly indicated by **Drawing No. 9**. The progressive development and recovery of drawdown around the mine for Years 1 - 10 is given in **Appendix 6**.

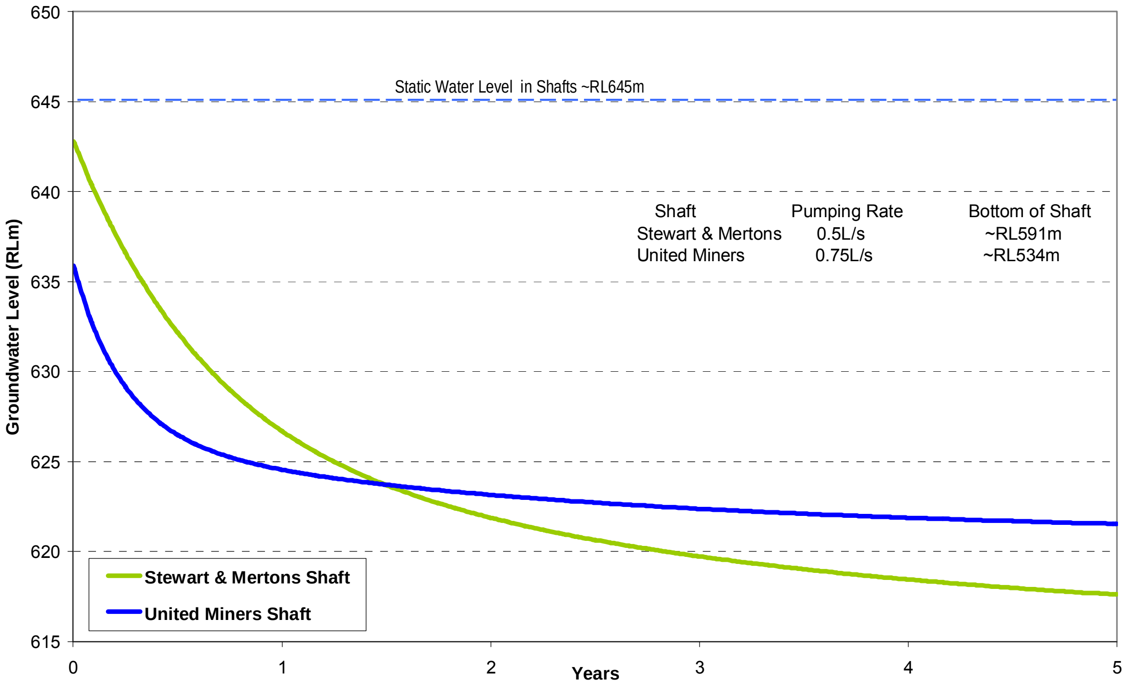

Figure 15 Predicted Drawdown in Stewart & Mertons and United Miners Workings

Drawing No. 9 indicates that there is between 1m to 5m of drawdown in the alluvium and underlying regolith along Majors Creek and that this occurs over a 1.5km reach of the creek. **Drawing No. 8** however indicates that while groundwater levels have been reduced by between 1-5m in the area of Majors Creek, there is still groundwater flow and discharge from the granodiorite to the creek except for a possible very small section near the confluence with North Creek, where flow gradients may be reversed. This means that groundwater discharge from the granodiorite will continue to the Majors Creek alluvium but at a lesser rate than for pre-mining conditions due to a flatter water table gradient caused by mine dewatering, and that only along a very small section near North Creek is there potential for groundwater to be lost from the alluvium to the mine. This is discussed further in the next section.

13.5 IMPACT ON MAJORS CREEK AND SPRING CREEK

13.5.1 Impact on Alluvial Aquifers of Majors Creek

Groundwater discharge or baseflow from the surrounding regolith and granodiorite aquifers is a prime source of the flow in Majors Creek and of recharge to its associated alluvium, particularly during periods of low rainfall when there is no surface runoff. As discussed, direct rainfall and runoff from the side slopes is a minor source of recharge to the alluvium.

It is noted that the outer limit of the cone of depression shown in **Drawing No. 9** incorporates approximately 1.5km of Majors Creek downstream of the village of Majors Creek. In order to asses the impact of the Project the creek, the base flow to the 1.5km reach of the creek and alluvium was modelled for the pre-mining situation and again at the end of Year 5, the end of mining. The results were then compared to determine the maximum impact of mine dewatering and pumping from the old shafts on the alluvial aquifer and potentially flow in Majors Creek.

The model indicated that steady state base flow to the 1.5km reach of Majors Creek is about 3.5L/s pre-mining and reduces to about 1.8L/s at the end of mining, as shown on **Figure 16**. The figure shows that the Dargues Reef Mine will steadily reduce base flow to the creek as the cone of drawdown around the mine increases, reducing the water table gradient to the creek and capturing part of the groundwater that would normally discharge into the section of creek. At the end of mining the maximum reduction in base flow from the granodiorite aquifer to the alluvial aquifer or the creek is expected to be about 1.7L/s (54ML/year).

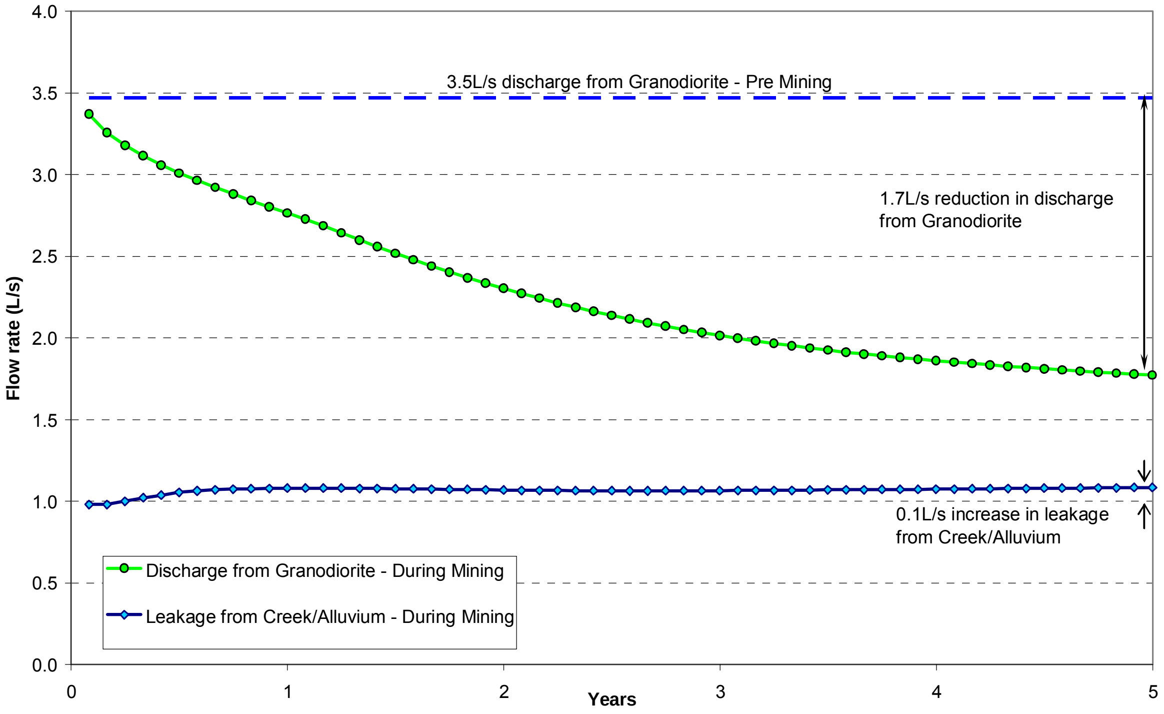

Figure 16 Simulated Reduction in Discharge and Increase in Leakage – Majors Creek

There is also a reversal of the flow gradient back towards the Dargues Reef Mine in the vicinity of the confluence of North and Majors Creeks, although the area over which this occurs is very limited, as shown on **Drawing No. 8**. This reversal of flow induces leakage from the alluvium down into the underlying bedrock. A water budget for the alluvial aquifer along the 1.5km section of the creek was obtained from the model in order to assess leakage from the alluvium due to mining activities. It should be noted that the ‘Flow-In’ and ‘Flow-Out’ in the budget file may include some ‘out’ and ‘re-enter’ components due to changes in aquifer bottom elevations, or to the normal direction of the boundary with respect to local hydraulic gradients. This resulted in a pre-mining “leakage loss” of about 1L/s as shown on **Figure 16**, which may not occur in reality but which is a peculiarity in the model. Predictive modelling indicates that the loss of water from the alluvium at the end of mining is 1.1L/s and that therefore leakage from the alluvium to the underlying bedrock as a result of mining is expected be about 0.1L/s (3.2ML/year). This is consistent with the water level contour/ groundwater flow directions shown on **Drawing No. 8**.

The total impact of the Project on Majors Creek is to reduce alluvial water/creek flow by up to 1.8L/s, about 0.16ML/day. Of this, 1.7L/s is through the interception of groundwater flow from the granodiorite aquifer prior to it discharging to the creek and becoming alluvial or surface water. The balance is induced leakage from the alluvial aquifer to the granodiorite aquifer and potentially the mine at a rate of 0.1L/s.

Subsequent to completion of mining the reduction in discharge from the granodiorite aquifer and leakage from the alluvial aquifer decreases as groundwater levels recover. At the end of Year 10, five years after completion of mining, there is no leakage from the alluvium and discharge to Majors Creek has essentially returned to pre-mining conditions, as shown on **Table 10**.

13.5.2 Impact on Base Flow to Spring Creek and on the Spring

Predictive modelling indicates that the cone of drawdown from mine dewatering extends over all of Spring Creek as shown on **Drawing Nos. 9**, and therefore baseflow and spring flow will cease, the groundwater from the granodiorite aquifer discharging to the mine rather than to the creek and spring. Flow gauging at the V-notch weir indicates a baseflow of about 0.3L/s (9.5ML/year) that will be captured by the mine. This continues throughout the mining period and for up to 5 years post mining as shown on **Table 10**, as the cone of drawdown over the majority of Spring Creek does not recover fully in that time.

13.6 IMPACT ON EMBARGOED WATER

As described in Section 4.2 there is currently an embargo on alluvial groundwater and surface water, and applications for licences to access this water will not be granted. The embargo however does not apply to groundwater from deeper aquifer, that is, from the granodiorite or regolith aquifers. Modelling has shown that the impact of mining reduces discharge from the granodiorite and regolith to the alluvium of Majors Creek by about 1.7L/s and surface water monitoring indicates that the base flow to the colluvium and spring of Spring Creek will be reduced by about 0.3L/s. That is there is a total reduction of groundwater discharge from the granodiorite of about 2L/s. The groundwater in the granodiorite is intercepted by mine dewatering and pumping from the old shafts before it reaches the alluvium and becomes embargoed water, that is, the water is taken from the deeper aquifers and is therefore not embargoed water.

Seepage from the alluvium to the mine or shafts where the groundwater flow gradient has been reversed, that is from the small area of Majors Creek near its confluence with the tributary North Creek, is however embargoed water. Modelling indicates that the rate of seepage out of the alluvial aquifer is about 0.1L/s (3.2ML/year).

13.7 IMPACT ON ARALUEN WATER SUPPLY

As discussed the township of Araluen which is located on Araluen River about 20km south-east of the Project Site is largely dependent on groundwater for its water supply, the majority of which is obtained from the unconsolidated aquifers on which the township is located. The Project Site is at the very head of the Araluen River catchment, with Majors Creek being a tributary of Araluen River. Araluen is approximately 157m AHD and therefore is at a much lower elevation than the Project Site where the elevation at the proposed Dargues Reef Mine is about 670m AHD.

Predictive modelling of the radius of influence of mine dewatering indicates that the cone of drawdown and extent of depressurization of the granodiorite and regolith aquifers does not extend to the Araluen Escarpment located to the south east of the mine and the township of Majors Creek. Therefore any discharge that may occur from these aquifers along the escarpment will not be impacted, the only impact being related to the reduction in discharge to Spring and Majors Creeks, and seepage from the alluvium of Majors Creek to the mine, as described in Sections 13.5 and 13.6.

The Department of Land and Water Conservation (1999)[3] estimated that the total sustainable yield of the unconsolidated aquifers of the Araluen River catchment is between 8028 and 8218ML/year. Of this, modelling has indicated that the Project will reduce discharge to the alluvium and in a small area induce seepage from the alluvium, at a maximum combined rate of 2.1L/s (66ML/year). Therefore the Project will reduce the total sustainable yield of the catchment by 0.8%. Given this very small percentage, the fact and that Araluen is at a much lower elevation and some 20km downstream from the Project Site, and that recharge to the alluvial and regolith aquifer systems that supply the town with water is dominated by local sub-catchment conditions, it is concluded that the Project will have no impact on groundwater supplies at Araluen.

As discussed at the end of Year 10, five years after completion of mining, there is no leakage from the alluvium and discharge to Majors Creek has essentially returned to pre-mining conditions, as shown on **Table 10**.

13.8 IMPACT ON SHOALHAVEN RIVER CATCHMENT

The radius of influence of mine dewatering as assessed by the 1m drawdown contour extends into the Shoalhaven River catchment as shown on **Drawing No. 9**. The cone of depression extends below the upper catchment of a number of small tributary creeks reducing discharge from the granodiorite aquifer to these creeks. The creeks were represented in the predictive model by drain cells and analysis of the model output pre-mining and again at completion of mining indicates a maximum reduction in discharge of 0.42L/s (13.5ML/year) in Years 5 and 6.

At the end of Year 10, five years after completion of mining, discharge from the granodiorite aquifer to the Shoalhaven River Catchment has essentially returned to pre-mining conditions, as shown on **Table 10**.

Table 10
Reduction in Groundwater Discharge to Catchments/Creeks (L/s)

from	to	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Moruya Catchment											
Granodiorite aquifer	Spring Creek	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Granodiorite aquifer	Majors Creek	0.7	1.2	1.5	1.6	1.7	1.2	0.6	0.3	0.1	0.05
Alluvial aquifer	Granodiorite aquifer	0.05	0.1	0.1	0.1	0.1	0	0	0	0	0
Shoalhaven Catchment											
Granodiorite aquifer	Shoalhaven Catchment	0	0.1	0.2	0.31	0.42	0.42	0.4	0.32	0.22	0.1

13.9 IMPACT ON OTHER GROUNDWATER USERS

13.9.1 Town and Farm Bores

The bores on the NOW database all appear to be outside of the radius of influence of mine dewatering shown on **Drawing No. 9** and similarly the majority of the bores and wells identified by the bore census are outside of the radius of influence, as defined by the 1m drawdown contour. The exception is two wells (Nos. 16 and 17), located in the upper catchment of Shingle Hut Creek and a small creek of the Shoalhaven River catchment respectively. The predicted drawdown of the water table in this area is between about 4m to 7m and given that the facilities are wells and are probably relatively shallow, it is possible that they will become dry during the period that the mine is operating, and for up to five years post mining. Similarly there are bores which are near or within the 1m drawdown contour, but given that these are 30m deep bores, they should not go dry.

There is also one bore (No. 18) and one well (No. 20) in the upper catchment of Jembaicumbene Creek and No. 6 which are about 30m deep and are located on the 1m drawdown contour, **Drawing No. 9**. The water level in these bores may decline by up to a metre as a result of mine dewatering, however as groundwater levels are likely to fluctuate by more than a metre the impact should not be discernable.

A monitoring program is recommended in Section 17 which includes a subset of key privately owned bores and the three bores discussed above plus one or two bores in the township should form this subset. In addition, the Proponent will undertake consultation with the owners of these bore to ensure that appropriate measures are implemented to minimise Project-related impacts.

13.9.2 Groundwater Dependent Ecosystems

Although the model predicts that groundwater discharge to the Majors Creek alluvium and leakage from the alluvium will be about 1.8L/s, groundwater in the alluvium and flow in the creek will be maintained by discharge from the bedrock aquifers both within the mine area, although at a reduced rate, and upstream of the area of impact of the mine. The 1.7L/s reduction in discharge is a loss from a very small area of the catchment and baseflow to the Majors Creek and the alluvium will be maintained from the much larger catchment area. Therefore any aquatic and riparian ecosystems associated with Majors Creek should not be impacted by the Project.

Conversely any groundwater dependent flora or fauna communities associated with the spring on Spring Creek will be impacted by the spring going dry during the mining period, and for up to 3 years post mining (see Section 13.10). It is noted, however, that the Ecology Assessment states that this section of Spring Creek contains primarily regenerating wattles, disturbed land and Ribbon Gum – Snow Gum grassy open forest.

13.10 IMPACT ON GROUNDWATER QUALITY

The groundwater quality data, discussed in Section 10.2, indicates that the groundwater in the granodiorite and regolith is of marginally poorer quality to that of the alluvial aquifer. However there is potential for the quality of the groundwater in the granodiorite to be impacted by the waste rock produced by mining, and discharge of this water to impact the quality of surface water and alluvial groundwater along Majors Creek. The Nett Acid Generating (NAG) potential of a number of samples of the waste rock that will be stockpiled and used to fill the mined out stopes was tested by the ALS Laboratory Group. The sample locations and the results of the analysis are given in **Table 11** below, which indicates a NAG of <0.1kg H_2SO_4/tonne. As such the waste rock will not cause acid mine drainage when the underground is flooded with groundwater and will not impact on the groundwater quality of the granodiorite or regolith aquifers.

Table 11
Nett Acid Generating Potential of Waste Rock

Sample No	**Hole**	**Depth (m)**	**Location**	**pH (OX) (pH Unit)**	**NAG (pH 4.5) (kg H_2SO_4/t)**	**NAG (pH 7.0) (kg H_2SO_4/t)**
DR_AGP01	DREX202	168-170	footwall to lode	8.9	<0.1	<0.1
DR_AGP02	DREX188	39-40	diorite in hanging wall	10.2	<0.1	<0.1
DR_AGP03	DREX190	111-114	granodiorite	8.4	<0.1	<0.1
DR_AGP04	DREX193	169-172	lode/ore	8.2	<0.1	<0.1
DR_AGP05	DREX193	181-182	just below ore, footwall	9.9	<0.1	<0.1
DR_AGP06	DREX193	157-158	diorite just above ore	10.3	<0.1	<0.1
DR_AGP07	DREX193	187-188	granodiorite footwall to mineralisation	10.4	<0.1	<0.1

It is therefore concluded that a significant change in the quality of groundwater in the granodiorite and regolith aquifers and consequently in alluvial groundwater quality, or base flow quality in Majors Creek, is not expected to occur as a result of the Project.

13.11 GROUNDWATER RECOVERY

Once mining operations cease, dewatering of the mine and a mine water supply from the historic workings will not be required and a slow recovery in groundwater levels in the area will occur over time.

Predictive modelling was undertaken to simulate 100 years of groundwater recovery post mining utilising the predicted groundwater levels and aquifer hydraulic properties at the end of the mining period. In order to simulate the stopes that had been backfilled with waste rock the specific yield of the mine workings was changed to 0.35 (35%) for the recovery prediction, to enable the model to simulate filling of the available void space in the stopes. All drain cells used to simulate dewatering from the Dargues Reef Mine were removed at the end of Year 5 and the simulation of pumping from the historic workings was ceased. This allows the groundwater levels in the granodiorite and the overlying regolith to recover.

At the cessation of mining there is a relatively steep groundwater gradient around the mine and a relatively high rate of inflow, however as the mine void begins to fill the gradient is reduced and the rate of groundwater inflow slows. The recovery of groundwater levels is shown on **Figure 17** which indicates that the majority of recovery occurs within the first year post mining, but that it then takes another 4 years before groundwater levels are fully recovered, that is groundwater levels are fully recovered after about 5 years post mining.

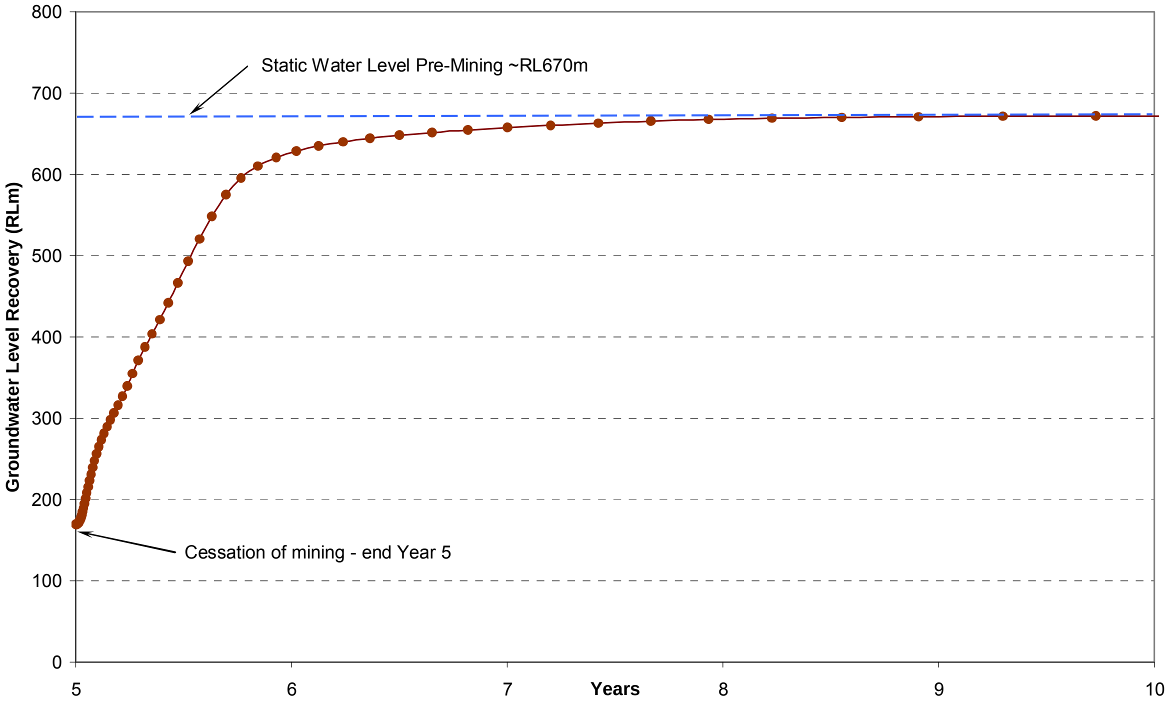

Figure 17 Predicted Recovery of Groundwater Level in Dargues Reef Mine

As groundwater levels recover post mining groundwater flow and discharge will return to the pre-mining levels. The groundwater level drawdown and recovery contours for years 1-8 are given in **Appendix 6**.

14. MODEL UNCERTAINTY AND LIMITATIONS

Development, calibration and the results of predictive simulations from any groundwater model is based on available data characterising the groundwater system under investigation. It is not possible to collect all the data characterising the whole aquifer system in detail and therefore various assumptions have to be made during development of the groundwater model. The Dargues Reef model has been constructed on limited data and use of the model predictions should be treated as such. Where assumptions were made the impact on the simulation results are discussed. Where an assumption was necessary, a conservative approach was taken such as adopting model parameters from plausible ranges, so that the model would likely over predict impacts or be representative of the worst case scenario.

Of particular note is that as there was no long term groundwater monitoring data on which to calibrate the model to transient conditions and hence to obtain calibration values for specific yield and specific storage, that is the storage of the aquifers. Hence there is some uncertainty with respect to the predicted inflow to the Dargues Reef Mine and the former workings. Two values representing a realistic, typical range were adopted for simulation of the granodiorite and should give inflow data that can be relied on.

The model assumed that the hydraulic properties of the aquifers were uniform across the entire model domain. In reality the permeability of the aquifers is variable and this variability can result in a less uniform zone of depressurisation than that predicted by the numerical model. Faults, inferred and known, were built into the model and simulated, however the hydraulic characteristics of the faults is unknown and were obtained through the calibration process.

The uncertainty in the model results can be reduced through the collection of inflow data. If significant divergence is observed between the measured and model predicted inflows, revisiting the model and specifically, recalibration of the model parameters against the measured inflow data will reduce the model uncertainty and gain better predictions for the future.

Despite the current level of uncertainty the model is considered sufficiently accurate to gain an understanding of the impacts of the project on the groundwater regime and is therefore suitable for the purposes of the EIS.

15. MITIGATION OPTIONS

It is noted that the model predicts the following reductions on water flows within and surrounding the Project Site:

- Approximately 0.1L/s (3.2ML/year), of water within the alluvial aquifer associated with Majors Creek would flow back towards the Dargues Reef Mine. The Proponent acknowledges that this water is embargoed.
- Approximately 1.7L/s (54ML/year), of water within the granodiorite aquifer would not flow to Majors Creek or its associated alluvial aquifer. The Proponent contends that this water is not embargoed.
- Approximately 0.3L/s (9.5ML/year), of water within the granodiorite aquifer would not flow to Spring Creek. The Proponent contends that this water is not embargoed.
- Approximately 0.42L/s (13.5ML/year) of water within the granodiorite aquifer would not flow to creeks within the Shoalhaven Catchment. The Proponent contends that this water is not embargoed.

In relation to the 0.1L/s (3.2ML/year) of embargoed water that is expected to flow from Majors Creek, the following mitigation measures may be appropriate:

- Purchase of an existing licence from another groundwater user and transferring that licence allocation to the Project Site.
- Discharging an equivalent amount of water, with the agreement of NSW Office of Water, into Majors Creek at a rate of 0.1L/s downstream of where the flow gradient to the alluvium has between reversed, say at the confluence of Spring and Majors Creeks.

In relation to the Araluen River Catchment and the 1.7L/s (54ML/year) of non-embargoed water within the granodiorite aquifer that is expected to cease to flow to Majors Creek and the 0.3L/s (9.5ML/year), that is expected to cease to flow to Spring Creek, the following mitigation measures may be appropriate:

- Apply for a licence from NOW to cover the expected reduced discharge. It may be appropriate to include this amount of water in the Proponent's licence to extract water from the Dargues Reef Mine.
- Discharge an equivalent amount of water, with the agreement of NSW Office of Water, into Majors Creek at a rate of 2.0L/s (64ML/year), downstream of where the flow gradient to the alluvium has between reversed, say at the confluence of Spring and Majors Creeks.

In relation to the Shoalhaven River Catchment and the 0.42L/s (13.5ML/year) of non-embargoed water within the granodiorite aquifer that is expected to cease to flow to the tributary creeks, the following mitigation measure may be appropriate:

- Apply for a licence from NOW to cover the expected reduced discharge. Again it may be appropriate to include this amount of water in the Proponent's licence to extract water from the Dargues Reef Mine.

Where drawdown in the water table adversely impacts the water supply from wells or bores of other groundwater users, an arrangement should be made for make good provisions. The supply should be re-instated in consultation with the landowner in a manner agreed to by both parties; which may include options such as:

- deepening of the well or bore that has been impacted;
- construction of a new well or bore;
- providing a piped water supply from the mine.

16. WATER LICENCING

Various licences are required under the *Water Act 1912,* especially for construction and use of water management works or water bores. The main licences which may be required for the Project are those that are covered under Section 10 of the Water Act 1912. This section deals with licences *"to construct and use a work, and to take and use water, if any, conserved, or obtained by the work, and to dispose of the water for the use of occupiers of the land"*.

Under the Water Act 1912 a licence or authority is required to "extract groundwater by any type of bore, well, spearpoint, or groundwater interception scheme for all purposes including basic landholder rights". This includes the construction of an underground mine and the taking and using of groundwater entering the mine. As stated, the model predicts that groundwater inflow to the Dargues Reef Mine from the granodiorite and regolith aquifers is expected vary between about 7.2L/s and 10.1L/s (227-320ML/year). In addition 2.5L/s (78ML/year) may be pumped from the Snobs, Stewart and Mertons and United Miners mine shafts. Therefore the total maximum volume of groundwater extracted from the granodiorite and regolith aquifers is about 398ML/year, for which one or more licences will be required.

As discussed predictive modelling indicates that the rate of seepage out of the alluvial aquifer, that is of embargoed water, is expected to be about 0.1L/s (3.2ML/year), and this will need to be accounted for by trading; purchasing of an existing licence, or by release of water into Majors Creek, in consultation with NOW.

The installation of additional groundwater monitoring bores, if required in the future will also require bore licences.

17. GROUNDWATER MONITORING PROGRAM

This section of the report provides a recommended groundwater monitoring program that would provide both an on-going assessment of the impact of the Project and a proactive indicator of any adverse impacts on the groundwater regime should they eventuate.

17.1 MONITORING NETWORK

Eight dedicated monitoring bores were established for the groundwater investigation, three in the alluvium and immediate underlying regolith along Majors Creek, and five in the granodiorite to the north of the Dargues Reef Mine, as previously described. Of the bores in the granodiorite there are two pairs of bores (DRWB01 / 02 and DRWB03 / 04), where one is in the regolith at about 16m depth and the second in the fresh rock at about 60m depth. The third bore (DRWB05) is in the regolith at 15.5m depth. In addition to the established monitoring bore network five (5) open exploration holes have been selected to provide a broader coverage of the Project Site and the regional impact of the mine on groundwater levels in the granodiorite aquifer. The integrity of these exploration bores have been assessed to ensure that they are sustainable for monitoring. The PVC casing of each bore has been left protruding 0.5m above ground and a cap placed on the casing. A summary of the recommended monitoring bore network and bore details are given on **Table 12**, and the bore locations are shown on **Drawing No. 4.**

17.2 WATER LEVEL MONITORING PLAN

Manual monitoring of groundwater levels should be undertaken on all bores at three monthly intervals. While the data obtained from manual monitoring is suitable for identification of long term trends in groundwater levels it does not provide data on short term events such rainfall recharge that can occur within a three monthly monitoring cycle. Therefore it is recommended that electronic water level data loggers also be installed in monitoring bores at key sites, as follows and shown on **Drawing No. 4**.

- DRWB06 and DRWB07 to monitor the impact on groundwater in the alluvium/regolith along Majors Creek.
- at the sites of the paired bores (DRWB01 / 02 and DRWB03 / 04), to monitor the impact on groundwater in both the regolith and deeper granodiorite in the area of Spring Creek.
- MCRC022 next to the former Snobs workings and MCRC028 next to the former Stewart and Mertons and United Miners workings of the Mines with the objective of monitoring the impact of pumping on groundwater levels.

Table 12
Summary of Proposal Monitoring Network

Bore	Location[1]		Elevation (mAHD)		Depth (m)	Screen (mbGL)	Aquifer
	(mE)	(mN)	Ground	TOC			
Established Monitoring Bores							
DRWB01	748681.1	6063944.8	714.65	715.20	67	61.0 – 7.0	granodiorite
DRWB02	748676.6	6063945.8	714.67	715.24	15.9	9.9 – 15.9	regolith
DRWB03	749111.8	6063817.2	712.35	712.91	66.1	60.1 – 66.1	granodiorite
DRWB04	749115.8	6063814.4	712.72	713.29	16.5	10.5 – 16.5	regolith
DRWB05	749200.3	6063530.7	721.89	721.87	15.58	9.6 – 15.6	regolith
DRWB06	748848.7	6061994.6	632.34	632.98	6.45	3.45 – 6.45	alluvium
DRWB07	748724.7	6061835.4	636.72	637.17	11.25	5.25 – 11.25	alluvium
DRWB08	749240.0	6061796.4	627.38	628.01	11.22	5.12 – 11.12	Alluvium

Exploration Holes Suitable for Monitoring							
Bore	Location		TOC (RLm)	Depth (m)	Hole Dip (degrees)	Screen (mbGL)	Aquifer
	(mE)	(mN)					
MCRC010	749698.6	6063375.1	728.19	78	-60	open hole	granodiorite
MCRC011	749506.7	6063674.9	723.92	169	-60	open hole	granodiorite
MCRC018	749654.3	6061822.7	657.87	138	-55	open hole	granodiorite
MCRC022	748137.8	6062103.2	684.27	114	-54	open hole	granodiorite
MCRC029	748491.8	6061819.9	668.51	216	-55	open hole	granodiorite
Note 1: projection MGA94 Zone 56							

The data loggers should be set to monitor water level fluctuations at six-hour intervals. This would enable water level fluctuations due to rainfall recharge and pumping to be distinguished from potential water level declines due to depressurisation as a result of mine dewatering.

Groundwater levels in a subset of key privately owned bores within the simulated zone of depressurisation that are still operational and in-use should also be manually monitored every quarter.

17.3 WATER QUALITY MONITORING PLAN

Groundwater quality monitoring should be undertaken in six of the established monitoring bores (DRWB01, 02, 03, 04, 06 & 07). The water quality monitoring program should consist of:

- quarterly field measurements of water level, pH, temperature and electrical conductivity.
- laboratory analysis at 6 month intervals for:
  - alkalinity,
  - major cations and anions,
  - nutrients – (ammonia, nitrate, nitrite),
  - metals – (iron, lead, chromium, cadmium, zinc, arsenic, copper and nickel).

It is recommended that all groundwater monitoring, water level measurements and sample collection, storage and transportation be undertaken in accordance with the procedures outlined by the Murray Darling Basin Commission (Aug 1997)[11].

17.4 OPERATIONAL WATER SUPPLY AND MINE SEEPAGE MONITORING

It is also recommended that monitoring of mine water seepage into the Dargues Reef Mine should be undertaken, particularly of the volume and quality of the water pumped from the mine. Similarly the volume of water pumped from the former Snobs, Stewart and Mertons and United Miners workings should be recorded with an in-line flow meter and the water level of the old workings should be monitored at least at 3 month intervals. Laboratory analysis of water samples pumped from the Dargues Reef Mine and former workings should also be undertaken at 6 monthly intervals.

17.5 DATA MANAGEMENT AND REPORTING

It is recommended data management and reporting include:

- Annual assessment of departures from identified monitoring data trends. If consecutive monitoring data over a period of 6 months exhibit an increasing divergence, in an adverse impact sense, from the previous data, or from the established or predicted trend, then such departures should initiate further actions. These may include a need to conduct more intensive monitoring or to invoke impact re-assessment and/or mitigative measures.
- Formal review of depressurisation of the regolith/granodiorite and alluvial aquifers should be undertaken annually by a suitably qualified hydrogeologist. The validity of the model predictions should be re-assessed after 2 years of mining and if the data indicates significant divergence from the model predictions an updated or new groundwater model may need to be constructed for simulation of mining.
- Annual reporting of all water level and water quality data and analyses of the results and trends.

17.6 SUMMARY OF MONITORING PROGRAM

A summary of the proposed groundwater monitoring plan is given in **Table 13** below.

---

[11] Murray Darling Basin Commission, (Aug. 1997), *"Murray Darling Basin Groundwater Quality Sampling Guidelines",* Tech. Report No. 3, Groundwater Working Group.

Table 13
Summary of Proposed Monitoring Plan

Bore/Mine	Groundwater Level		Groundwater Quality		Pumping/Discharge Volume
	Manual	**Data Loggers**	**Field**	**Laboratory**	
DRWB01	quarterly	Yes – 6 hourly	quarterly	6 monthly	
DRWB02	quarterly	Yes – 6 hourly	quarterly	6 monthly	
DRWB03	quarterly	Yes – 6 hourly	quarterly	6 monthly	
DRWB04	quarterly	Yes – 6 hourly	quarterly	6 monthly	
DRWB05	quarterly				
DRWB06	quarterly	Yes – 6 hourly	quarterly	6 monthly	
DRWB07	quarterly	Yes – 6 hourly	quarterly	6 monthly	
DRWB08	quarterly				
MCRC010	quarterly				
MCRC011	quarterly				
MCRC018	quarterly				
MCRC022	quarterly	Yes – 6 hourly			
MCRC029	quarterly	Yes – 6 hourly			
Snobs	quarterly		quarterly	6 monthly	continuous
Stewart & Mertons	quarterly				continuous
United Miners	quarterly		quarterly	6 monthly	continuous
Dargues Reef Mine			quarterly	6 monthly	continuous
Landowner Bores	quarterly		quarterly		

Drawings

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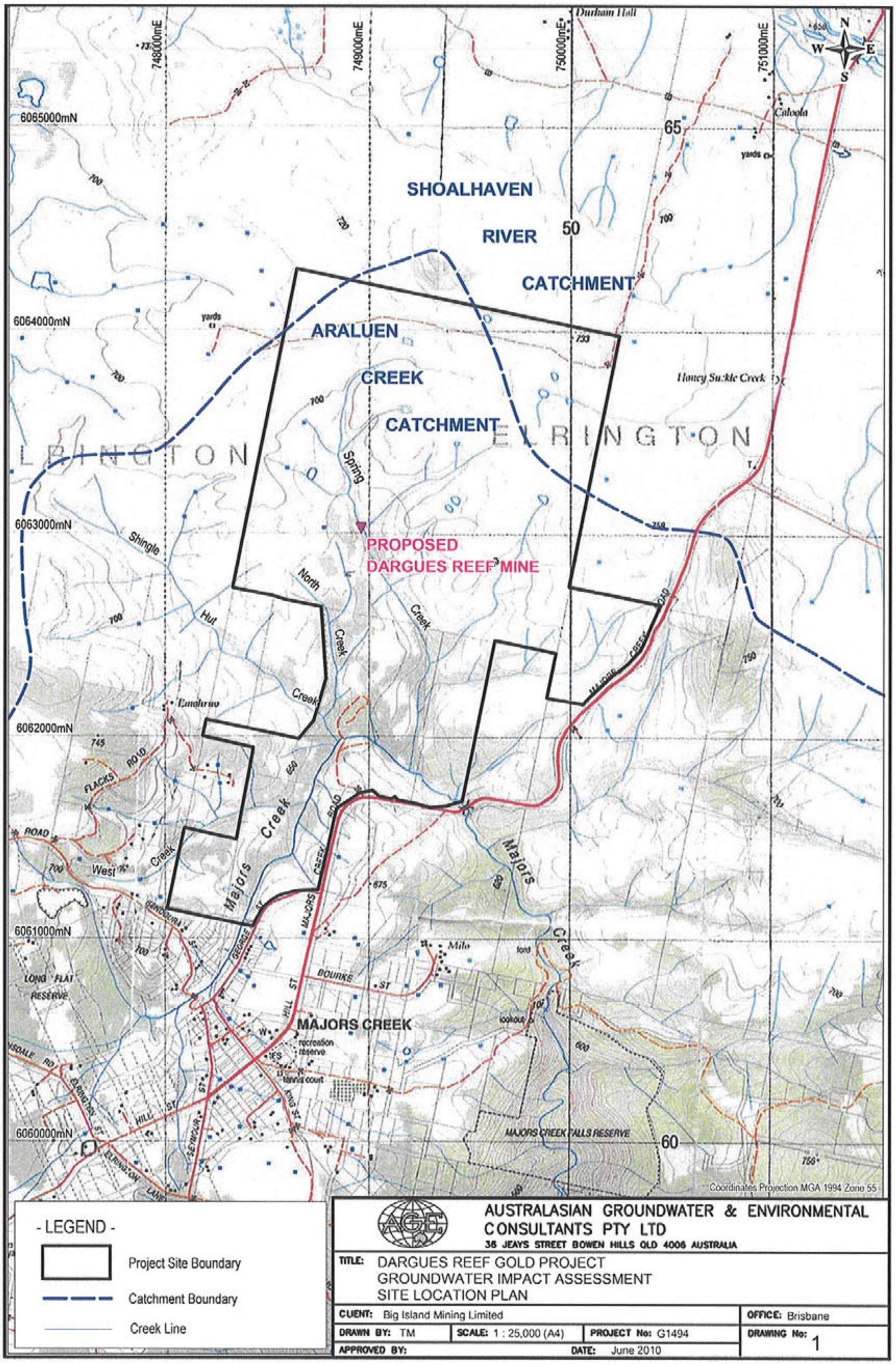
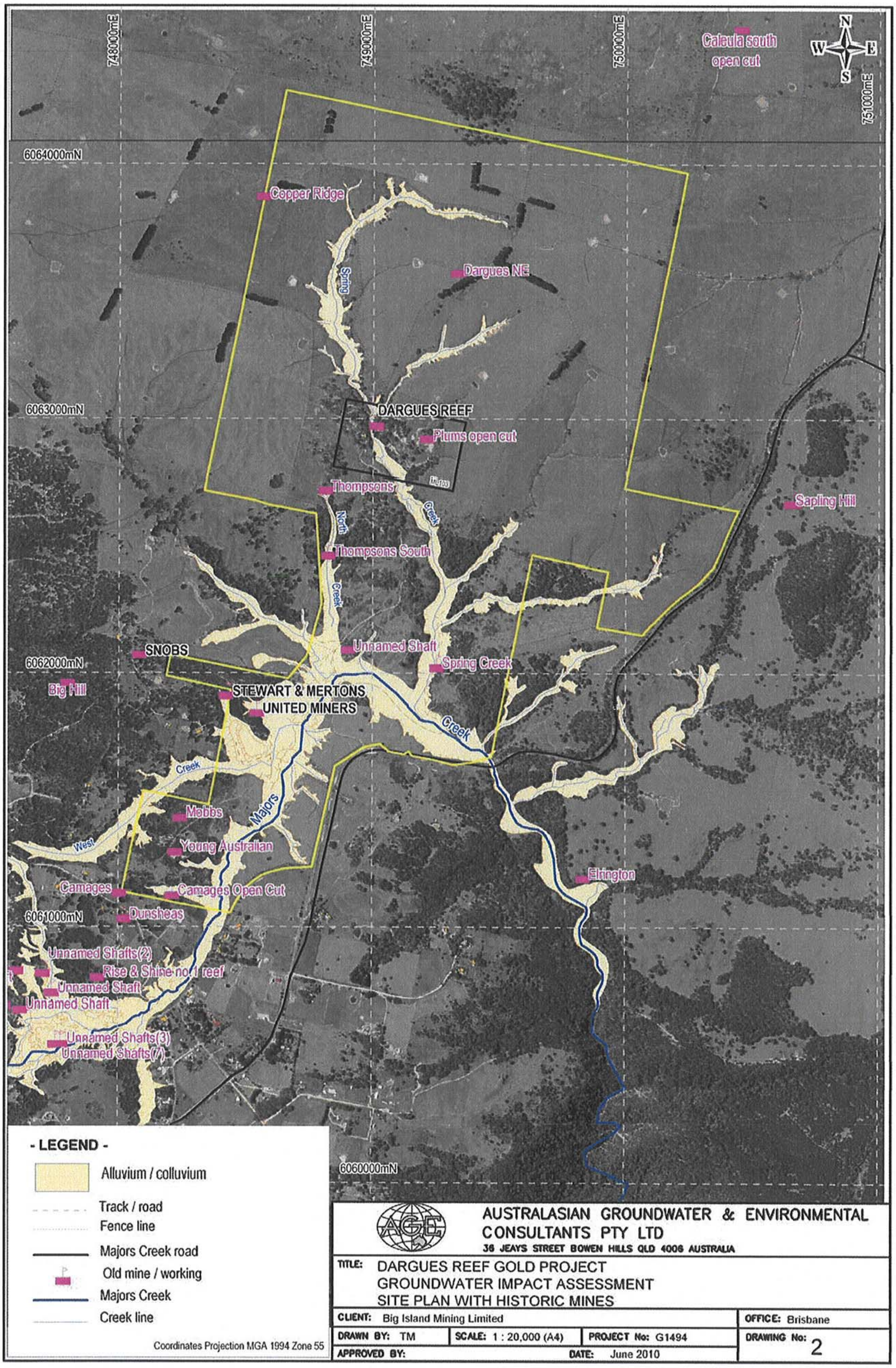


AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
38 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: DARGUES REEF GOLD PROJECT
GROUNDWATER IMPACT ASSESSMENT
SITE LOCATION PLAN

CLIENT: Big Island Mining Limited			OFFICE: Brisbane
DRAWN BY: TM	SCALE: 1 : 25,000 (A4)	PROJECT No: G1494	DRAWING No: 1
APPROVED BY:		DATE: June 2010	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6061000mN
6060000mN
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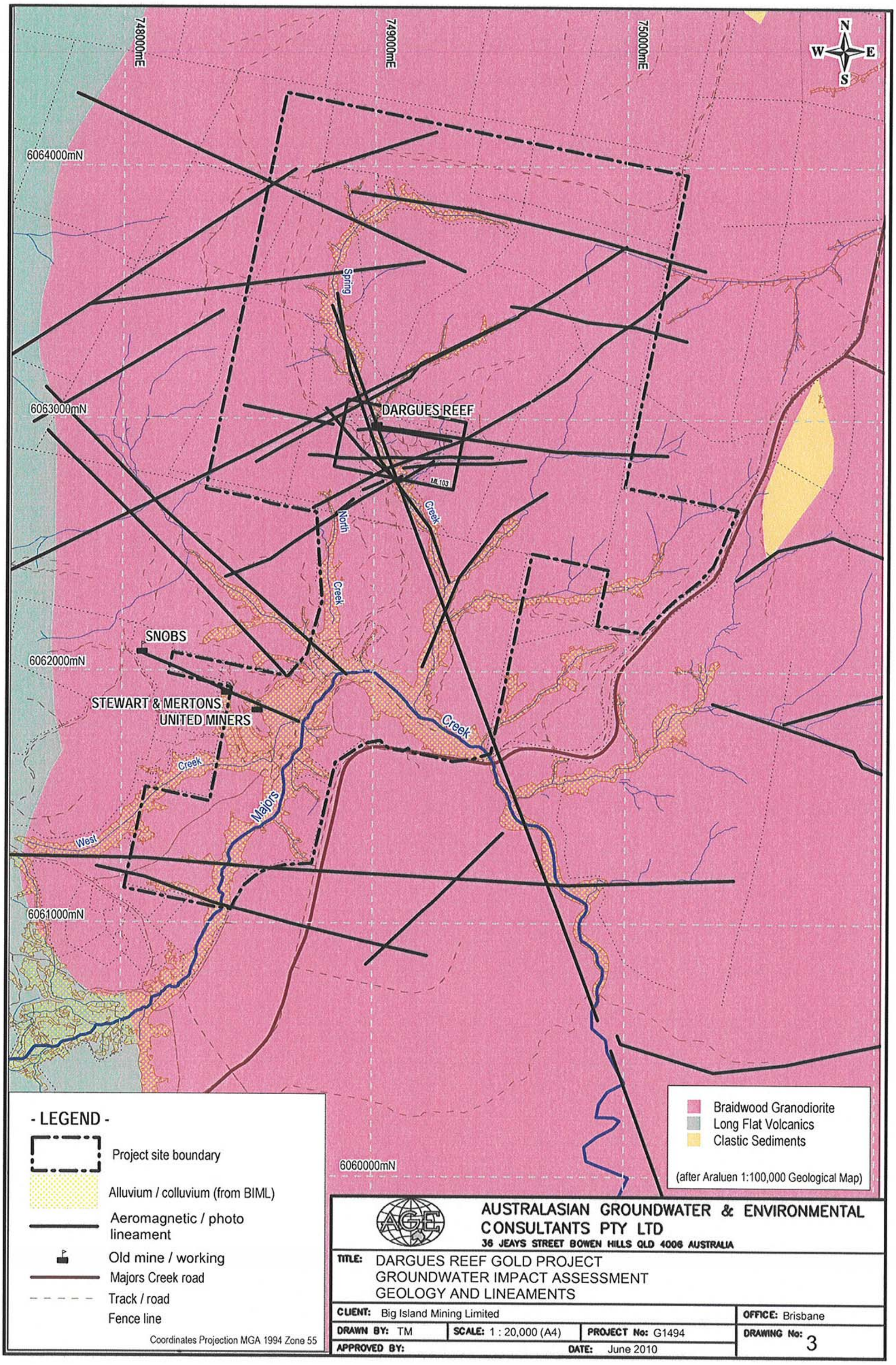
Caleula south open cut
Copper Ridge
Dargues NE
Spring
DARGUES REEF
Plums open cut
Thompsons
North
Creek
Thompsons South
Sapling Hill
Unnamed Shaft
Spring Creek
SNOBS
Big Hill
STEWART & MERTONS
UNITED MINERS
Creek
Majors
Mobbs
West
Young Australian
Camages
Camages Open Cut
Dunsheas
Elrington
Unnamed Shafts(2)
Rise & Shine no 1 reef
Unnamed Shaft
Unnamed Shaft
Unnamed Shafts(3)
Unnamed Shafts(7)
- LEGEND -
Alluvium / colluvium
Track / road
Fence line
Majors Creek road
Old mine / working
Majors Creek
Creek line
Coordinates Projection MGA 1994 Zone 55
AGE
AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA
TITLE: DARGUES REEF GOLD PROJECT
GROUNDWATER IMPACT ASSESSMENT
SITE PLAN WITH HISTORIC MINES
CLIENT: Big Island Mining Limited
OFFICE: Brisbane
DRAWN BY: TM
SCALE: 1 : 20,000 (A4)
PROJECT No: G1494
DRAWING No: 2
APPROVED BY:
DATE: June 2010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Spring
DARGUES REEF
ML103
North
Creek
Creek
SNOBS
STEWART & MERTONS
UNITED MINERS
Creek
Creek
Majors
West
- LEGEND -
Project site boundary
Alluvium / colluvium (from BIML)
Aeromagnetic / photo lineament
Old mine / working
Majors Creek road
Track / road
Fence line
Coordinates Projection MGA 1994 Zone 55
Braidwood Granodiorite
Long Flat Volcanics
Clastic Sediments
(after Araluen 1:100,000 Geological Map)
AGE
AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA
TITLE: DARGUES REEF GOLD PROJECT
GROUNDWATER IMPACT ASSESSMENT
GEOLOGY AND LINEAMENTS
CLIENT: Big Island Mining Limited
OFFICE: Brisbane
DRAWN BY: TM
SCALE: 1 : 20,000 (A4)
PROJECT No: G1494
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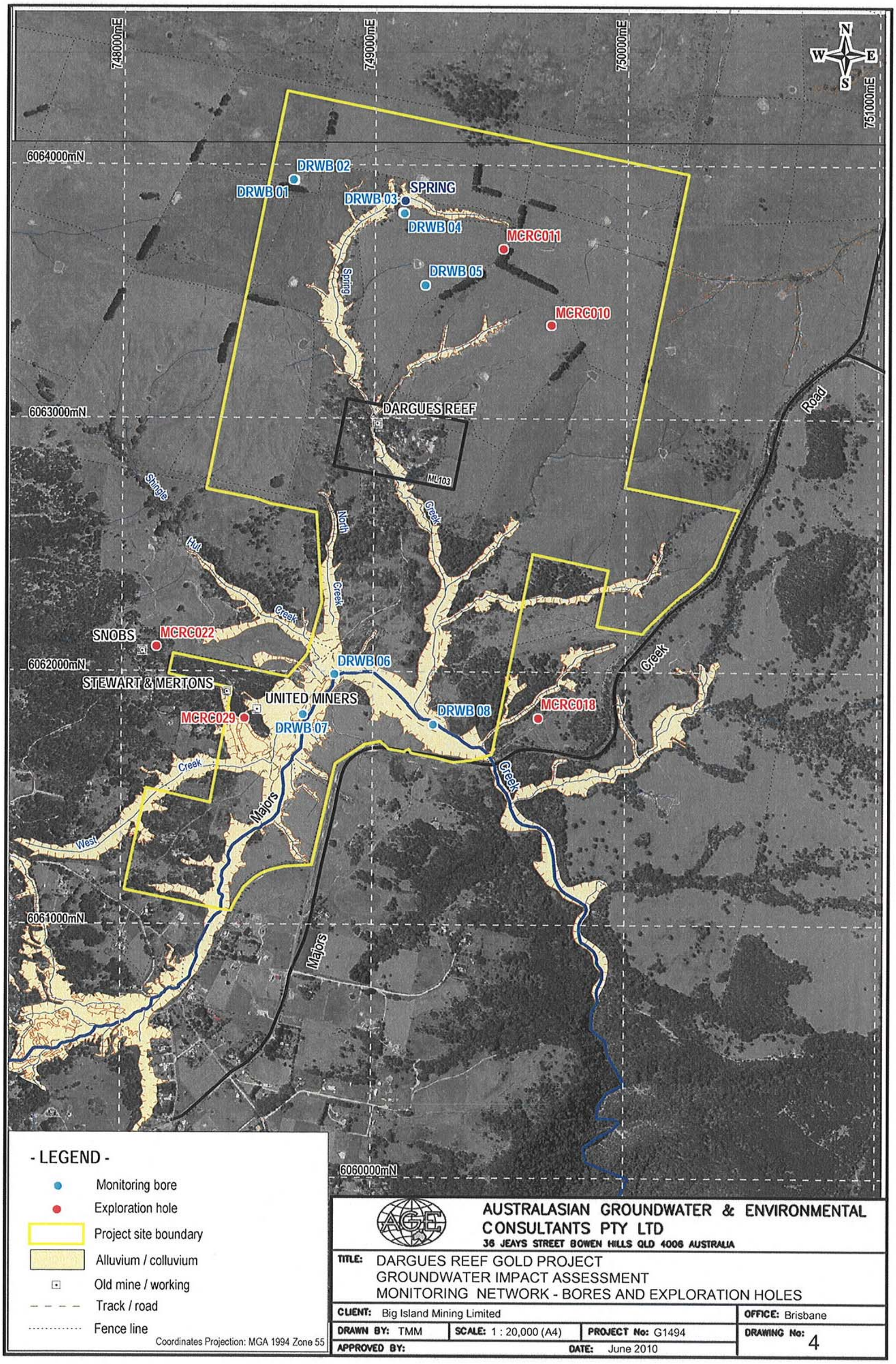
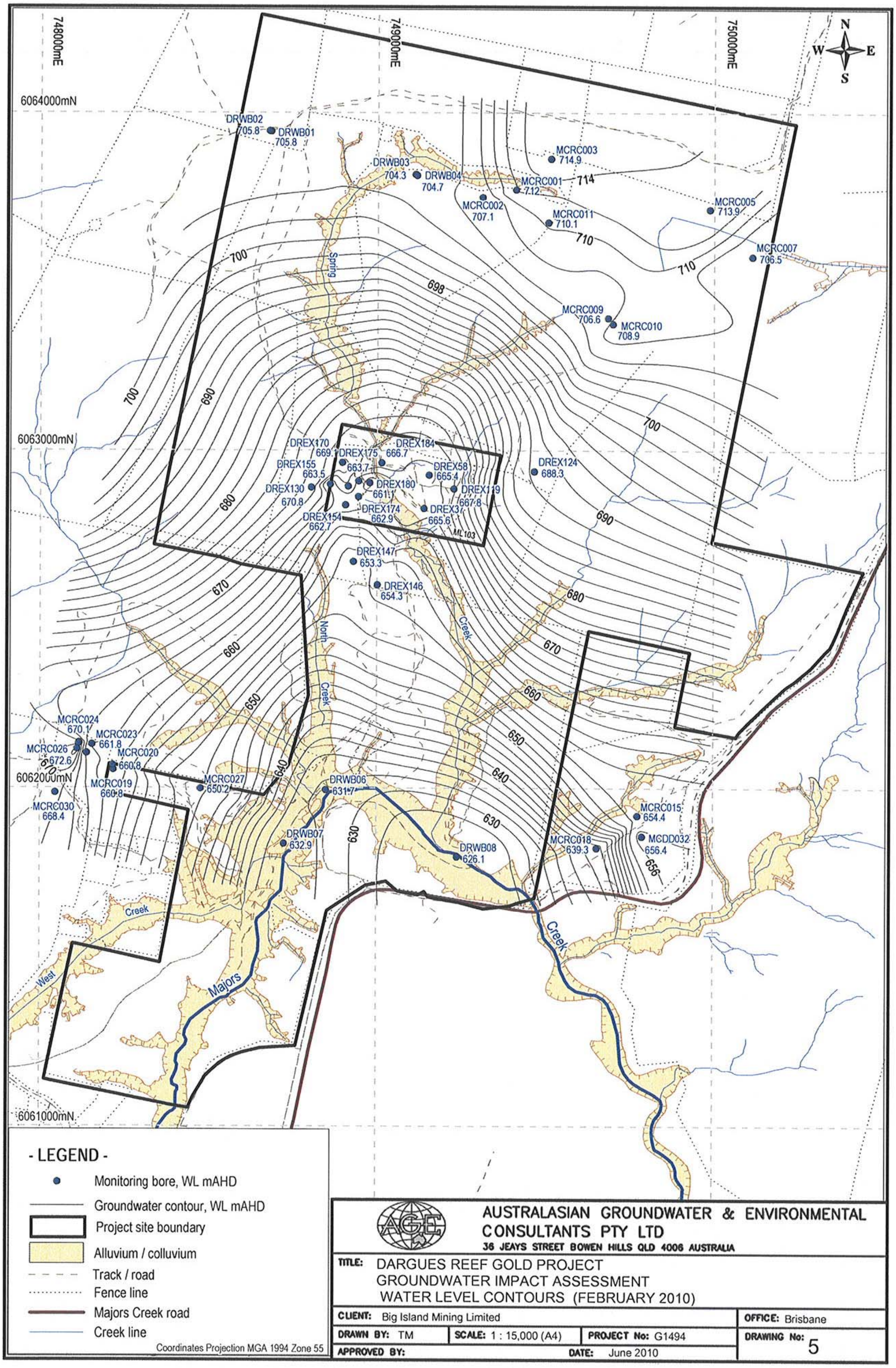
APPROVED BY:
DATE: June 2010



AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: DARGUES REEF GOLD PROJECT
GROUNDWATER IMPACT ASSESSMENT
MONITORING NETWORK - BORES AND EXPLORATION HOLES

CLIENT: Big Island Mining Limited
OFFICE: Brisbane
DRAWN BY: TMM
SCALE: 1 : 20,000 (A4)
PROJECT No: G1494
DRAWING No: 4
APPROVED BY:
DATE: June 2010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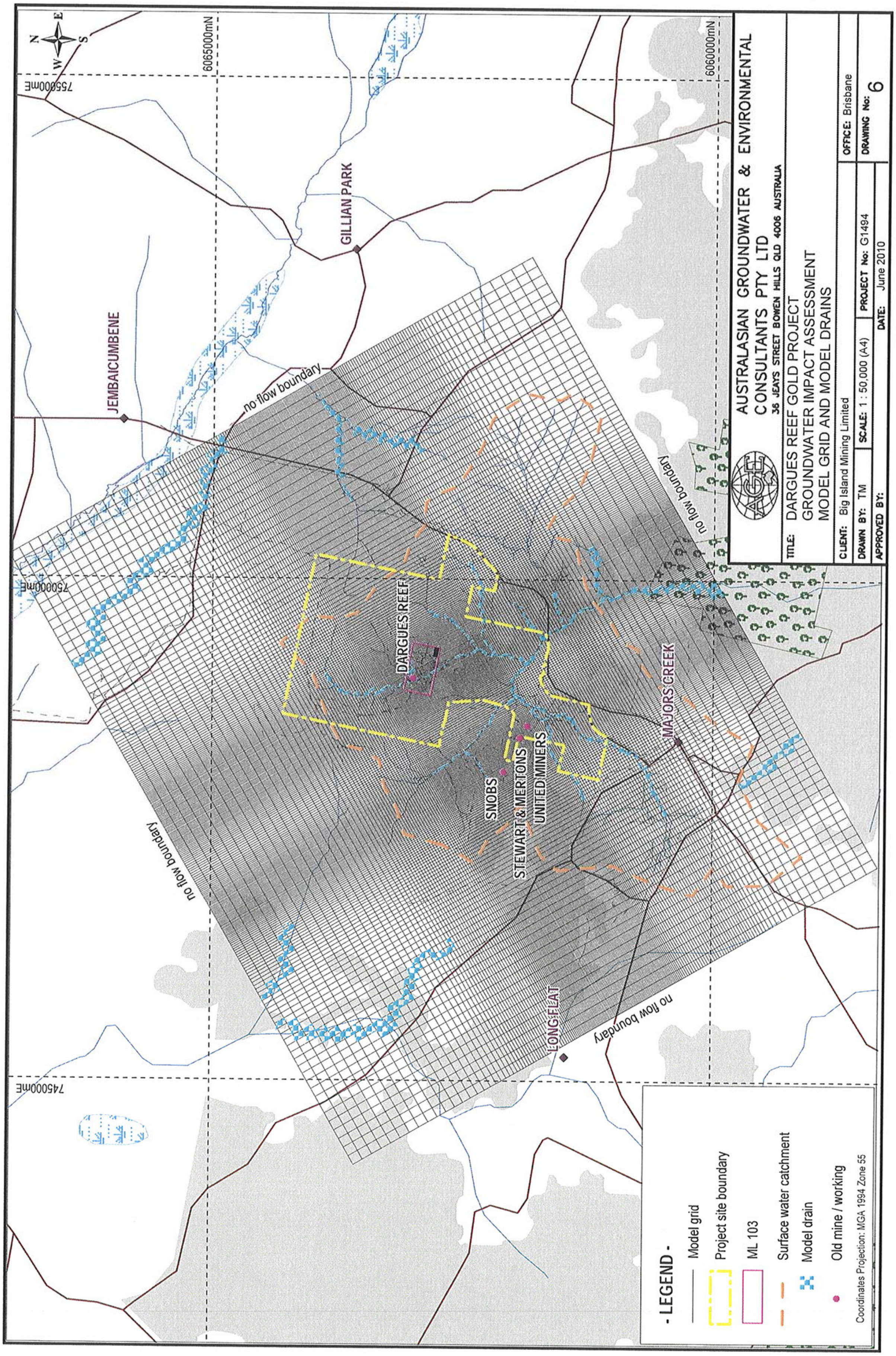
DRWB02 705.8
DRWB01 705.8
DRWB03 704.3
DRWB04 704.7
MCRC003 714.9
MCRC001 712
714
MCRC002 707.1
MCRC011 710.1
MCRC005 713.9
MCRC007 706.5
710
700
698
MCRC009 706.6
MCRC010 708.9
Spring
690
DREX170 669.1
DREX175 663.7
DREX184 666.7
DREX155 663.5
DREX58 665.4
DREX180 661.1
DREX130 670.8
DREX119 667.8
DREX174 662.9
DREX37 665.6
DREX154 662.7
ML 103
DREX124 688.3
680
DREX147 653.3
DREX146 654.3
670
North
Creek
660
650
640
630
MCRC024 670.1
MCRC023 661.8
MCRC026 672.6
MCRC020 660.8
MCRC019 660.8
MCRC027 650.2
MCRC030 668.4
DRWB06 631.7
DRWB07 632.9
DRWB08 626.1
MCRC018 639.3
MCRC015 654.4
MCDD032 656.4
656
West
Creek
Majors
Creek
- LEGEND -
Monitoring bore, WL mAHD
Groundwater contour, WL mAHD
Project site boundary
Alluvium / colluvium
Track / road
Fence line
Majors Creek road
Creek line
Coordinates Projection MGA 1994 Zone 55
AGE
AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA
TITLE: DARGUES REEF GOLD PROJECT
GROUNDWATER IMPACT ASSESSMENT
WATER LEVEL CONTOURS (FEBRUARY 2010)
CLIENT: Big Island Mining Limited
OFFICE: Brisbane
DRAWN BY: TM
SCALE: 1 : 15,000 (A4)
PROJECT No: G1494
DRAWING No: 5
APPROVED BY:
DATE: June 2010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GILLIAN PARK
JEMBAICUMBENE
no flow boundary
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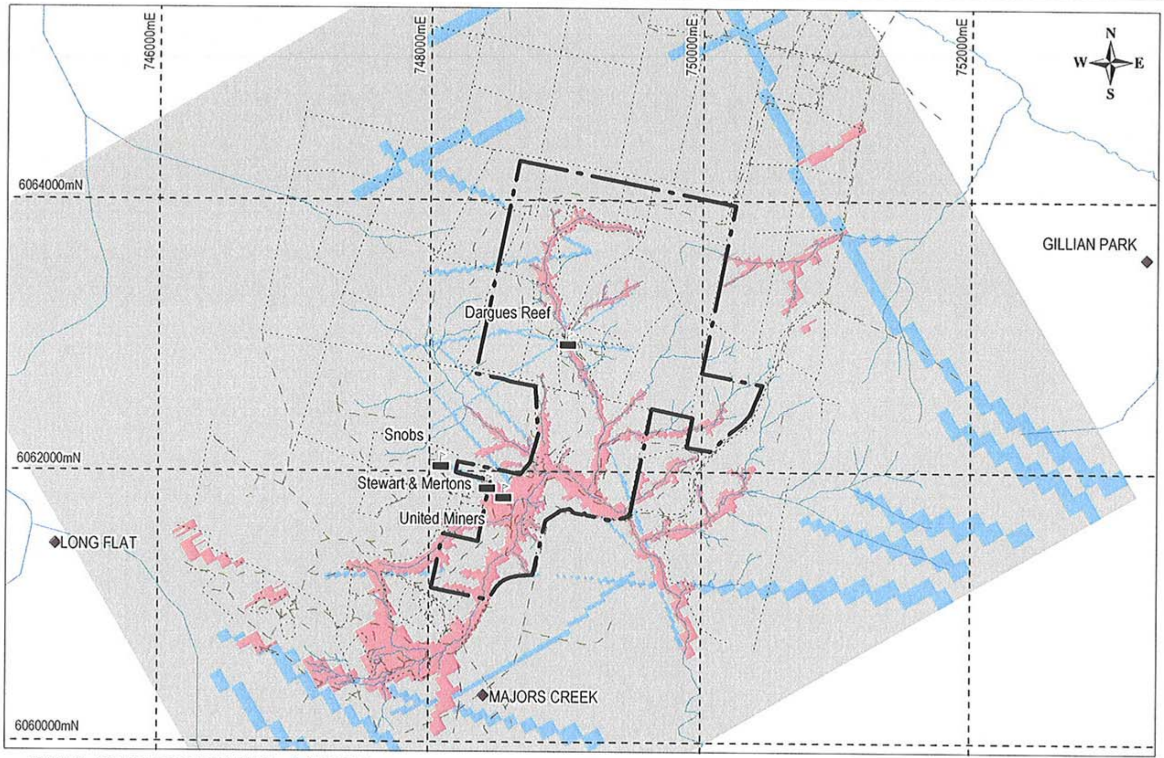
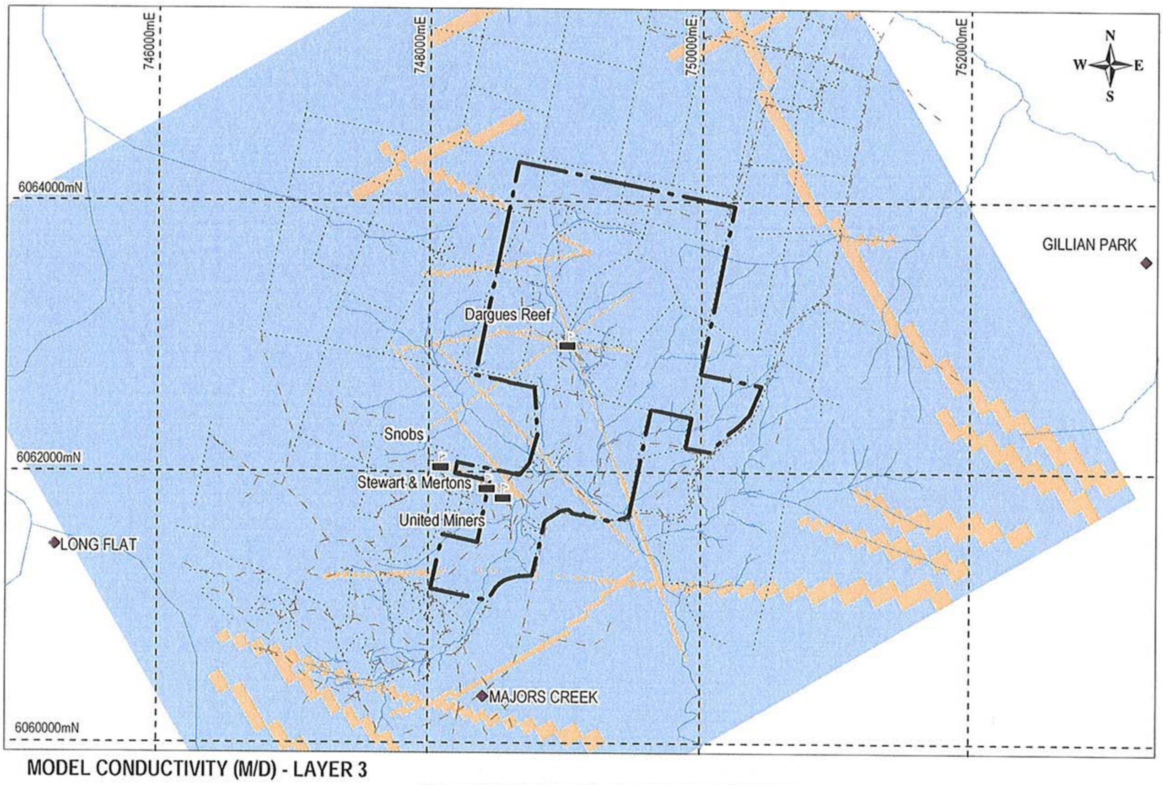
no flow boundary
no flow boundary
DARGUES REEF
MAJORS CREEK
SNOBS
STEWART & MERTONS
UNITED MINERS
LONG FLAT
AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA
TITLE: DARGUES REEF GOLD PROJECT GROUNDWATER IMPACT ASSESSMENT MODEL GRID AND MODEL DRAINS
CLIENT: Big Island Mining Limited
DRAWN BY: TM
SCALE: 1 : 50,000 (A4)
PROJECT No: G1494
OFFICE: Brisbane
APPROVED BY:
DATE: June 2010
DRAWING No: 6
- LEGEND -
Model grid
Project site boundary
ML 103
Surface water catchment
Model drain
Old mine / working
Coordinates Projection: MGA 1994 Zone 55



MODEL CONDUCTIVITY (M/D) - LAYER 1



MODEL CONDUCTIVITY (M/D) - LAYER 3

- LEGEND - Hydraulic Conductivity (m/d)

🟥 2.7 - alluvium / colluvium
⬜ 0.16 - (regolith)
🟦 0.0029 - fault (regolith)
🟧 0.0019 - fault (granodiorite)
🟦 0.000038 - granodiorite

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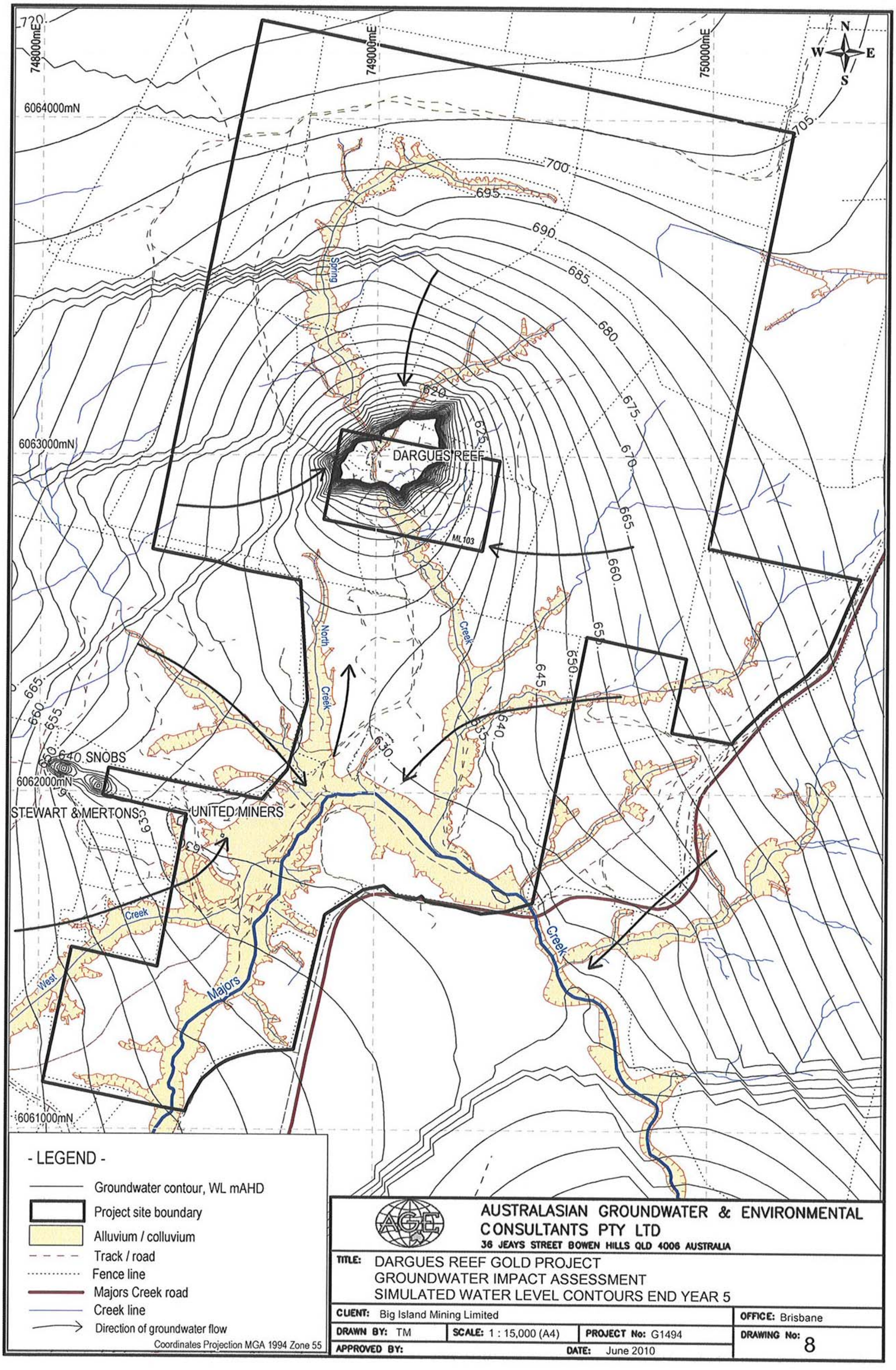
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: DARGUES REEF GOLD PROJECT
GROUNDWATER IMPACT ASSESSMENT
MODEL HYDRAULIC CONDUCTIVITY

CLIENT: Big Island Mining Limited
OFFICE: Brisbane
DRAWN BY: TM
SCALE: 1 :50,000 (A4)
PROJECT No: G1494
DRAWING No: 7
APPROVED BY:
DATE: June 2010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655
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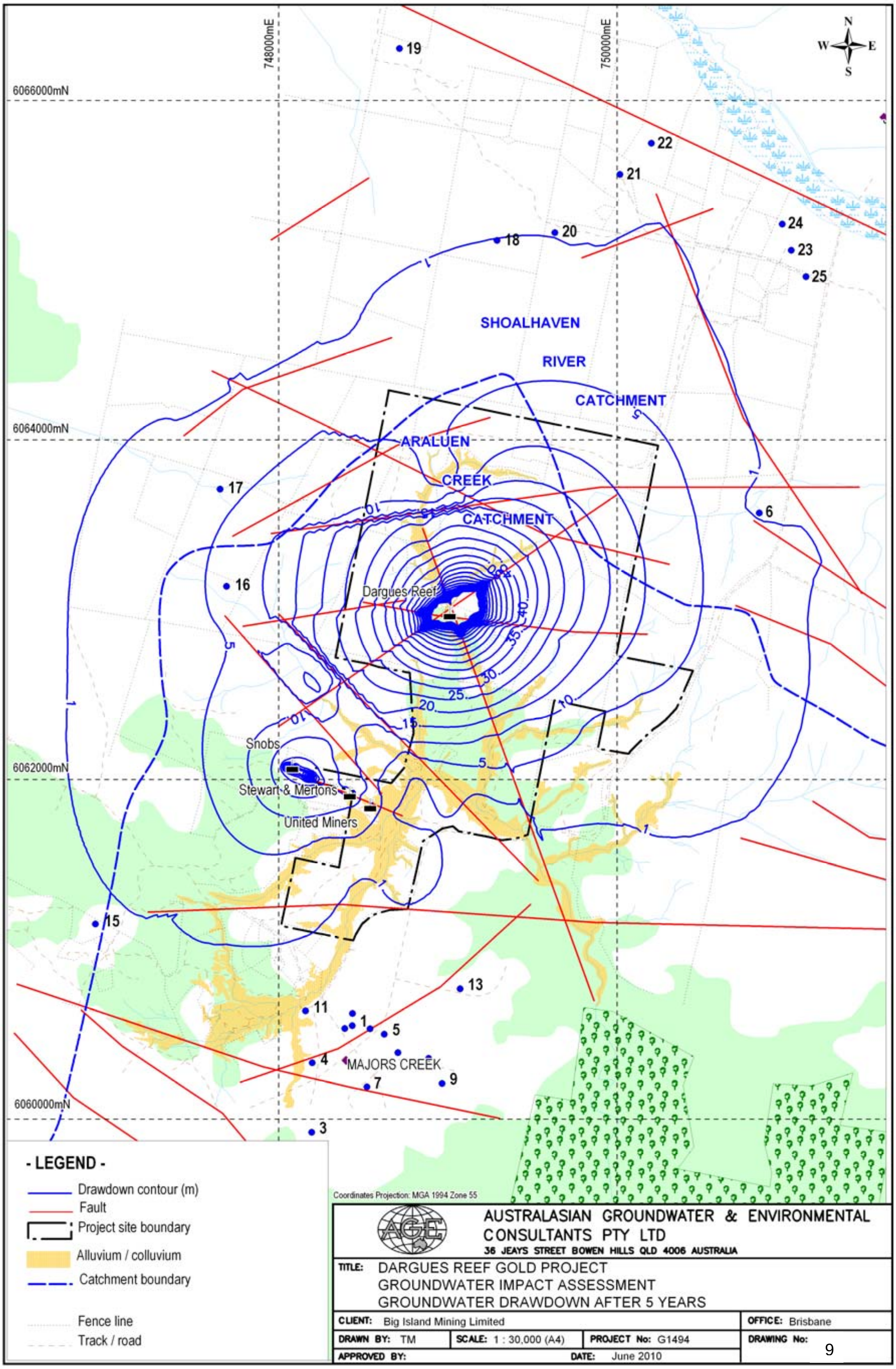
645
640
635
630
625
620
Spring
North Creek
Creek
DARGUES REEF
ML103
SNOBS
STEWART & MERTONS
UNITED MINERS
West
Creek
Majors
Creek
- LEGEND -
Groundwater contour, WL mAHD
Project site boundary
Alluvium / colluvium
Track / road
Fence line
Majors Creek road
Creek line
Direction of groundwater flow
Coordinates Projection MGA 1994 Zone 55
AGE
AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA
TITLE: DARGUES REEF GOLD PROJECT
GROUNDWATER IMPACT ASSESSMENT
SIMULATED WATER LEVEL CONTOURS END YEAR 5
CLIENT: Big Island Mining Limited
OFFICE: Brisbane
DRAWN BY: TM
SCALE: 1 : 15,000 (A4)
PROJECT No: G1494
DRAWING No: 8
APPROVED BY:
DATE: June 2010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9
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SHOALHAVEN
RIVER
CATCHMENT
ARALUEN
CREEK
CATCHMENT
Dargues Reef
Snobs
Stewart & Mertons
United Miners
MAJORS CREEK
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20
25
30
35
40
- LEGEND -
Drawdown contour (m)
Fault
Project site boundary
Alluvium / colluvium
Catchment boundary
Fence line
Track / road
Coordinates Projection: MGA 1994 Zone 55
AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA
TITLE: DARGUES REEF GOLD PROJECT
GROUNDWATER IMPACT ASSESSMENT
GROUNDWATER DRAWDOWN AFTER 5 YEARS
CLIENT: Big Island Mining Limited
OFFICE: Brisbane
DRAWN BY: TM
SCALE: 1 : 30,000 (A4)
PROJECT No: G1494
DRAWING No: 9
APPROVED BY:
DATE: June 2010

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Appendices

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Appendix 1

Director Generals Requirements

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Table A1.1
Director-General's Requirements
(Department of Planning – 23 April 2010)

Paraphrased Requirement	**Relevant EA Section(s)**
SOIL AND WATER	
Including:	
• a detailed site water balance:	**-**
• a detailed groundwater model;	**Section 12**
• potential water quality impacts on the environment and other land users; and	**Section 13.7**
• a description of the final landform water management;	**-**

Table A1.2
Coverage of Environmental Issues

Page 1 of 6

Government Agency	**Paraphrased Requirement**	**Relevant EA Section(s)**
	WATER	
Department of Environment, Climate Change & Water (01/04/10)	The EA must outline site layout, demonstrating efforts to avoid pollution to water resources (especially for activities with significant potential impacts eg tailings dam) and show potential areas of modification of contours, drainage etc.	**Environmental Assessment**
	The EA must provide details of the project that are essential for predicting and assessing impacts to waters: • including the quantity and physio-chemical properties of all potential water pollutants and the risks they pose to the environment and human health, including the risks they pose to Water Quality Objectives in the ambient waters (as defined on www.environment.nsw.gov.au/ieo, using technical criteria derived from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, ANZECC 2000); • the management of discharges with potential for water impacts; and • drainage works and associated infrastructure; land-forming and excavations; working capacity of structures; and water resource requirements of the proposal.	**Surface Water Assessment**
	The EA must outline how total water cycle considerations are to be addressed showing total water balances for the development (with the objective of minimising demands and impacts on water resources). Include water requirements (quantity, quality and source(s)) and proposed storm and wastewater disposal, including type, volumes, proposed treatment and management methods and re-use options.	**Surface Water Assessment**
	The EA should fully assess impacts including but not limited to the following:	
	• Groundwater quality issues including the alteration of the groundwater recharge rates and possible contamination of groundwater from the recycled water scheme;	**Section 13.7**

Table 3
Coverage of Environmental Issues (cont'd)

Page 2 of 6

Government Agency	Paraphrased Requirement	Relevant EA Section(s)
	WATER (cont'd)	
Department of Environment, Climate Change & Water (01/04/10)	• Altered flow and drainage regimes and subsequent effects on the dynamics and recharge ability of groundwater aquifers; and long-term effects on stability and integrity of aquifers;	**Section 13**
	• Impacts of altered flow and drainage regimes impacting on receiving waters including impact on creek morphology and ecosystem implications including aquatic ecology, riparian vegetation and weed distribution;	**Section 13.5**
	• Cumulative impacts of proposed recycled water discharges on the receiving waters – downstream impact of altered flows; effects to river health, ecology and biodiversity; and	**Not Applicable**
	• Construction impacts on waterways due to runoff and increased sediment and nutrient movement.	**Surface Water Assessment**
	The EA should provide details of the project that are essential for predicting and assessing impacts to waters including the quantity and physio-chemical properties of all potential water pollutants and the risks posed to the environment and human health, including the risks they pose to Water Quality Objectives in the ambient waters using technical criteria derived from the ANZECC Guidelines.	**Section 10.2**
Council (06/04/10)	Council is concerned about use of surface water and ground water that may potentially affect water resources in the area for the local community and environmental flows. It is Council's opinion that N0W approvals are required for use of dam and ground water associated with any use that is not for stock and domestic. The impact of water harvesting needs to be addressed in the EIS.	**Sections 13.5 13.6 13.7 13.9**
	'Adequate details with regard to monitoring of water quality and water quantity upstream and downstream of the proposed development need to be addressed in the EIS. Council is particularly concerned about the location of the tailings.	**Surface Water Assessment**
NSW Government Office of Water (01/04/10)	NOW requires the Environmental Assessment (EA) for the proposal to demonstrate that the proposed mining operation will achieve the following: • no impact on adjacent licensed water users, basic landholder rights, minimum base flows, or groundwater-dependent ecosystems; • adequate water licensing under the Water Act 1912 for proposed groundwater extraction and/or groundwater interception and compliance with the S.1 113A Water Act 1912 embargo on groundwater licences in the Coastal Floodplain Alluvial Groundwater Sources and Highly Connected Alluvial Groundwater Sources of Coastal Catchments – Regional NSW, which is provided as a supplement to this letter.	**Section 13.6** **Sections 15 16**

Table 4
Coverage of Environmental Issues (cont'd)

Page 3 of 6

Government Agency	Paraphrased Requirement	Relevant EA Section(s)
	WATER (cont'd)	
NSW Government Office of Water (01/04/10)	NOW requires the Environmental Assessment (EA) for the proposal to demonstrate the following;	
	1. Adequate and secure water supply.	**Sections 13.2 & 13.3**
	2. Identification of site water demands, water sources (surface and groundwater), water disposal methods and water storage structures in the form of a water balance. This is to also include details of any water reticulation infrastructure that supplies water to and within the site.	
	3. Proposed water management on the site based on the site water balance. This is to also include an outline of a proposed surface water and groundwater management plan.	**Section 17**
	4. A groundwater and surface water impact assessment on adjacent licensed water users, basic landholder rights, groundwater-dependent ecosystems and the surface water environment. This will require a detailed understanding of the existing and predicted surface and groundwater system.	**Sections 13.5 13.6 13.7 13.9**
	5. Requirement to intercept groundwater and predicted dewatering volumes, seepage volumes, water quality and disposal/retention methods. Intercepted and dewatered volumes need to be predicted throughout mine life and for any post mine life recovery period to reach equilibrium.	**Sections 13.2 13.3 13.10**
	6. An impact assessment of the construction, operation and final landform of the proposed onsite waste rock emplacements, tailings storage facility and other potentially contaminating facilities to meet the requirements of the NSW State Groundwater Policy framework document.	
	7. Identification of works or activities requiring licensing under the Water Act 1912 or Water Management Act 2000, eg. Monitoring bores, aquifer interception, groundwater and/or surface water extraction.	**Section 16**
	8. Proposal to construct watercourse crossings and carry out works within 40m of a watercourse in accordance with former DWE Controlled Activity Approval Guidelines.	
	9. Adequate mitigating and monitoring requirements to address surface and groundwater impacts.	**Section 17**
	The Environmental Assessment report must include the following for all water-related aspects of the proposal:	
	• an environmental risk analysis to identify potential environmental impacts associated with the project (construction and operation);	**Section 13.7.2**
	• proposed mitigation measures and potentially significant residual environmental impacts after the application of proposed mitigation measures; and	**Section 15**
	• where additional key environmental impacts are identified through this environmental risk analysis, an appropriately detailed impact assessment of these additional key environmental impacts must be included in the Environmental Assessment report.	

Table 5
Coverage of Environmental Issues (cont'd)

Page 4 of 6

Government Agency	Paraphrased Requirement	Relevant EA Section(s)
WATER (cont'd)		
NSW Government Office of Water (01/04/10)	The Environmental Assessment must include assessment of water supply and/or water interception and extraction against any Water Sharing Plan, or any embargo in force affecting the site or potential water supply to the proposal. A full description of water supply to all stages of the proposal must be included, which includes:	**Section 13.6**
	• water source(s) which may be used to supply water to the proposal, existing licences, additional water requirements, and a checklist against any regulatory water sharing or other ministerial plans or other instruments applying to that water source;	**Sections 13.2 & 13.3**
	• explanation of any embargoes or full commitment declarations for the proposal, and any identified means to source water supply for the proposal;	**Section 13.6**
	• examination of reliability of water supply to the proposal, including alternatives to site rainfall runoff harvesting in the event of drought;	**Sections 13.2 & 13.3**
	• demonstration of prioritisation and effective reuse of saline or other contaminated water within the proposal;	**–**
	• explanation of water circuitry and means to segregate contaminated, sediment-laden and clean water volumes within the proposal and proposal site.	**–**
	The Environmental Assessment report must include demonstration that the project is consistent with the spirit and principles of the NSW State Groundwater Policy Framework Document, the NSW State Groundwater Quality Protection Policy, the NSW State Groundwater Dependent Ecosystems Policy and the Draft NSW State Groundwater Quantity Management Policy, This must include, for the pre-, during, and post- development phases of the project the following:	
	• identification of surrounding water users and any groundwater dependent ecosystems;	**Sections 7.5 & 10.1**
	• detailed explanation of potential groundwater volume, piezometric level, water table heights and the direction of flow and quality, through mine life and projections into the post-mine period, any identified connected water sources impacted by mining;	**Section 13**
	• detailed explanation of groundwater drawdown or other impacts upon connected groundwaters;	**Section 13**
	• explanation of the site water balance, including any changes to water balance inputs from rainfall runoff, additional supplies, dewatering requirements and/or groundwater seepage;	**Section 13**
	• detailed description of any proposed water supply system utilising groundwater as a source, and assessment of current licensing arrangements against this;	**Section 13**

Table 6
Coverage of Environmental Issues (cont'd)

Page 5 of 6

Government Agency	**Paraphrased Requirement**	**Relevant EA Section(s)**
	WATER (cont'd)	
NSW Government Office of Water (01/04/10)	• detailed analysis of the impacts of dewatering if required for the project, identifying the magnitude and duration of pumping, the areal extent of water level drawdown, the likely quality of extracted groundwater, alterations to site water balance, and the monitoring and reporting protocols to be adopted to meet licensing requirements;	**Section 13**
	• measures to prevent contamination of the groundwater;	**–**
	• identification of potential and likely groundwater-dependent ecosystems, and any impact upon these ecosystems which may result from the proposal; this must include Terrestrial vegetation with seasonal or episodic reliance on groundwater, and Aquatic and riparian ecosystems in, or adjacent to, streams or rivers dependent upon the input of groundwater to minimum base flows.	**Section 13.7.2**
	The Environmental Assessment report must include demonstration that the project is consistent with the spirit and principles of the NSW State Rivers and Estuaries Policy, Wetlands Management Policy, and relevant groundwater policies defined below. This must include, for the pre-, during, and post- development phases of the project the following: • general description of channel form, river style or other descriptive category of any affected channel, including identification of key geomorphologic indicators and conditions within the zone of influence for the proposal (ie either between most distant riverine controls surrounding the area of disturbance to the proposal area, and/or within the area of groundwater depressurisation); • hydrologic character of the riverine system, stream energy and power relationships, energy relationships at bankfull height and at peak flow and assessment of stream power and critical tractive stress for existing and any modified conditions for any rivers affected by the proposal, which provides details of: o long profile and cross sectional survey along the channel, and identification of at least the closest upstream and downstream controls on the channel; o assessment of bed and bank material, identification of critical entrainment and destabilisation thresholds; o assessment of the constriction and resultant change in afflux through, past or over the structure, and resultant changes in energy profiles involving the structure; o nature of bedload transport, and mechanism(s) to permit bedload transport through the structure. • procedures to develop stream relocation and reconstruction criteria which utilise best practice management, which must include the principles which underpin any embargoes currently in force under the Water Act, 1912, or operational rules of any Water Sharing Plan in force over the site;	**Surface Water Assessment**

Table 7
Coverage of Environmental Issues (cont'd)

Page 6 of 6

Government Agency	Paraphrased Requirement	Relevant EA Section(s)
WATER (cont'd)		
NSW Government Office of Water (01/04/10)	• methodologies by which proposed relocation or reinstatement of watercourses will be undertaken, and whether any proposed ecological offset provisions will provide adequate protection to any instream or groundwater dependent ecosystems which exist on the site; • Mechanism to maintain long profile grade through the structure, or to provide energy dissipation through the structure at the re-entry point design volumes/velocity downstream; • Nature of existing controls along all watercourses on the site, and proposed use of engineered structures and vegetation to provide long term control to the channel; • final configuration of any relocation, modification or other impact upon rivers and watercourses on or surrounding the site, including geomorphic character mimicking conditions of undisturbed rivers or watercourses adjacent to the proposal area.	**Surface Water Assessment**
	The Environmental Assessment report must include: • justification of the proposed final landform with regard to its impact on local and regional groundwater systems; • a detailed description of how the site would be progressively rehabilitated and integrated into the surrounding landscape; • detailed modelling of potential groundwater volume, flow and quality impacts of the presence of an inundated final void on identified receptors specifically considering those environmental systems that are likely to be groundwater dependent; • a detailed description of the measures to be put in place to ensure that sufficient resources are available to implement the proposed rehabilitation; and • the measures that would be established for the long-term protection of local and regional aquifer systems and for the ongoing management of the site following the cessation of the project.	**Section 12** **Section 17**

Appendix 2

Composite Logs – Monitoring Bores

(No. of pages excluding this page = 12)

(Note: A colour version of this Appendix is available on the Project CD)

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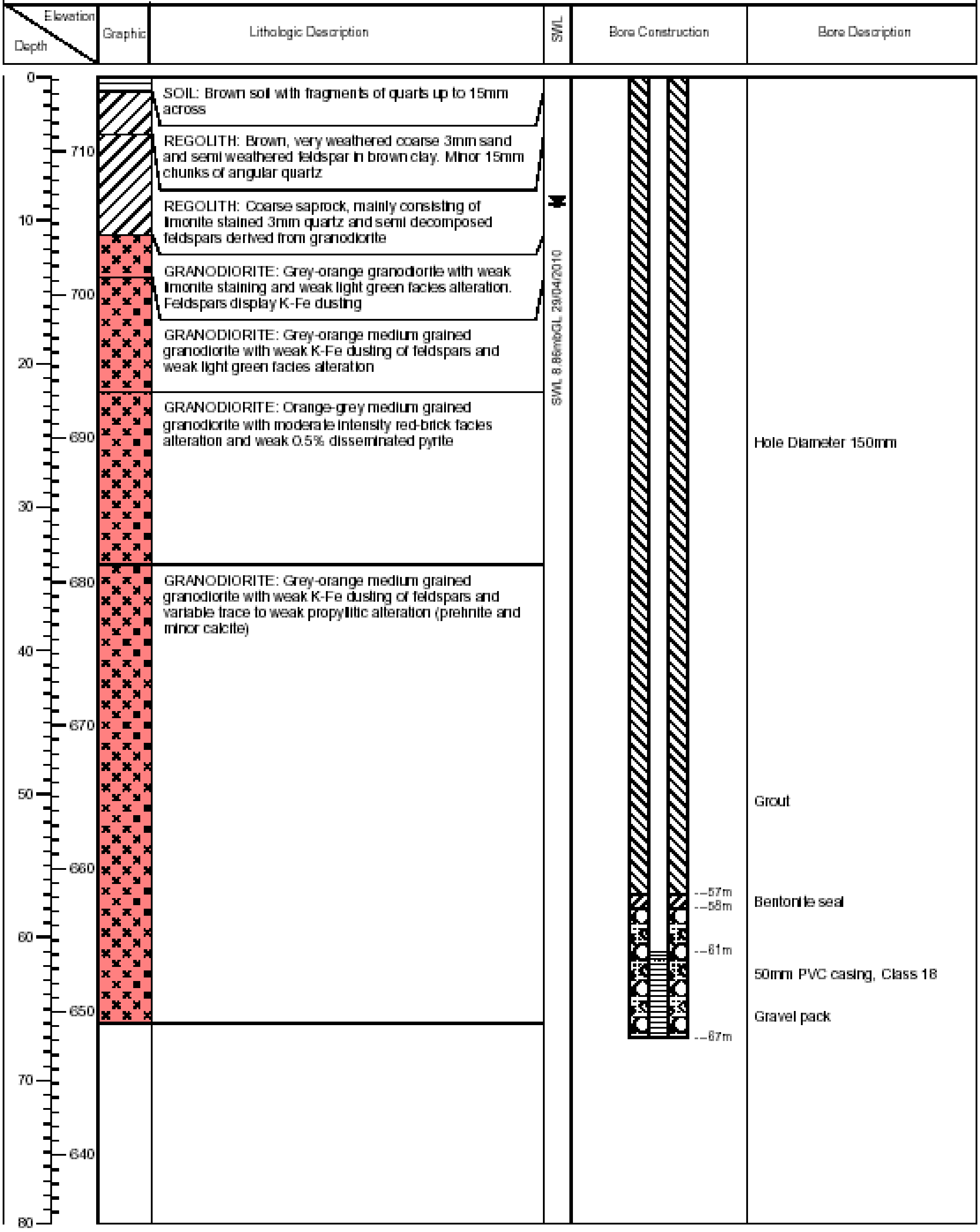
Australasian Groundwater & Environmental
Consultants Pty Ltd
36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **DRWB01** Page 1 of 1

PROJECT NO.	G1494	DRILLER:	Danny Hill	DATUM:	MGA GDA94
PROJECT NAME:	Dargues Reef Gold Project	DRILLING METHOD:	RAB	GROUND LEVEL:	714.654m
DATE:	16/04/2010	DRILL RIG:		TOP OF CASING LEVEL:	715.204m
CONTRACTOR:	Bungendore Water Bores	COORDINATES:	748681.1 mE; 6063945 mN	LOGGED BY:	CS



SOIL: Brown soil with fragments of quartz up to 15mm across

REGOLITH: Brown, very weathered coarse 3mm sand and semi weathered feldspar in brown clay. Minor 15mm chunks of angular quartz

REGOLITH: Coarse saprock, mainly consisting of limonite stained 3mm quartz and semi decomposed feldspars derived from granodiorite

GRANODIORITE: Grey-orange granodiorite with weak limonite staining and weak light green facies alteration. Feldspars display K-Fe dusting

GRANODIORITE: Grey-orange medium grained granodiorite with weak K-Fe dusting of feldspars and weak light green facies alteration

GRANODIORITE: Orange-grey medium grained granodiorite with moderate intensity red-brick facies alteration and weak 0.5% disseminated pyrite

GRANODIORITE: Grey-orange medium grained granodiorite with weak K-Fe dusting of feldspars and variable trace to weak propylitic alteration (prehnite and minor calcite)

Hole Diameter 150mm

Grout

Bentonite seal

50mm PVC casing, Class 18

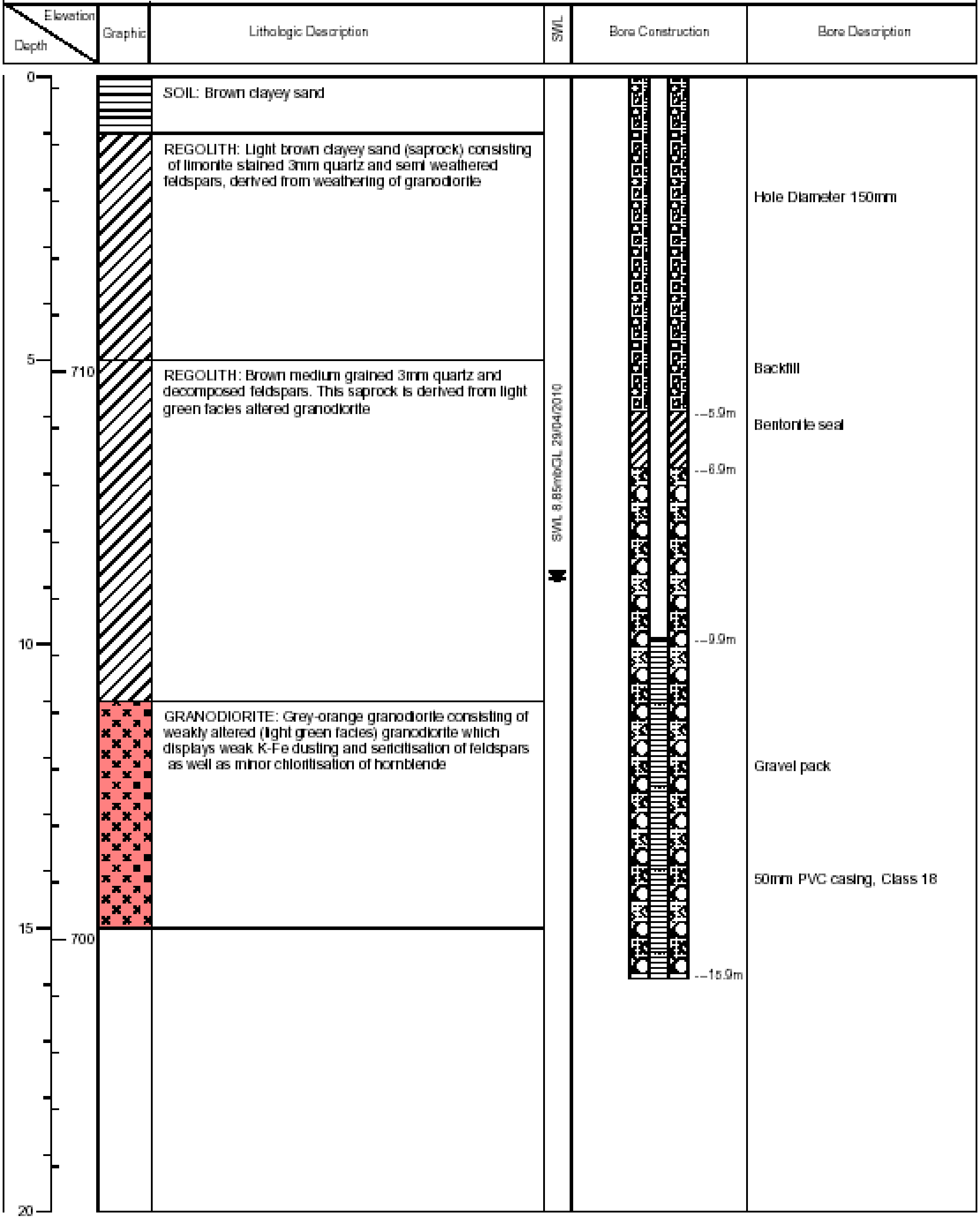
Gravel pack

Australasian Groundwater & Environmental Consultants Pty Ltd
36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: DRWB02 Page 1 of 1

PROJECT NO.	G1494	DRILLER:	Danny Hill	DATUM:	MGA GDA94
PROJECT NAME:	Dargues Reef Gold Project	DRILLING METHOD:	RAB	GROUND LEVEL:	714.672m
DATE:	16/04/2010	DRILL RIG:		TOP OF CASING LEVEL:	715.242m
CONTRACTOR:	Bungendore Water Bores	COORDINATES:	743676.6 mE; 6063946.0 mN	LOGGED BY:	CS



SOIL: Brown clayey sand

REGOLITH: Light brown clayey sand (saprock) consisting of limonite stained 3mm quartz and semi weathered feldspars, derived from weathering of granodiorite

REGOLITH: Brown medium grained 3mm quartz and decomposed feldspars. This saprock is derived from light green facies altered granodiorite

GRANODIORITE: Grey-orange granodiorite consisting of weakly altered (light green facies) granodiorite which displays weak K-Fe dusting and sericitisation of feldspars as well as minor chloritisation of hornblende

Hole Diameter 150mm

Backfill

Bentonite seal

Gravel pack

50mm PVC casing, Class 18

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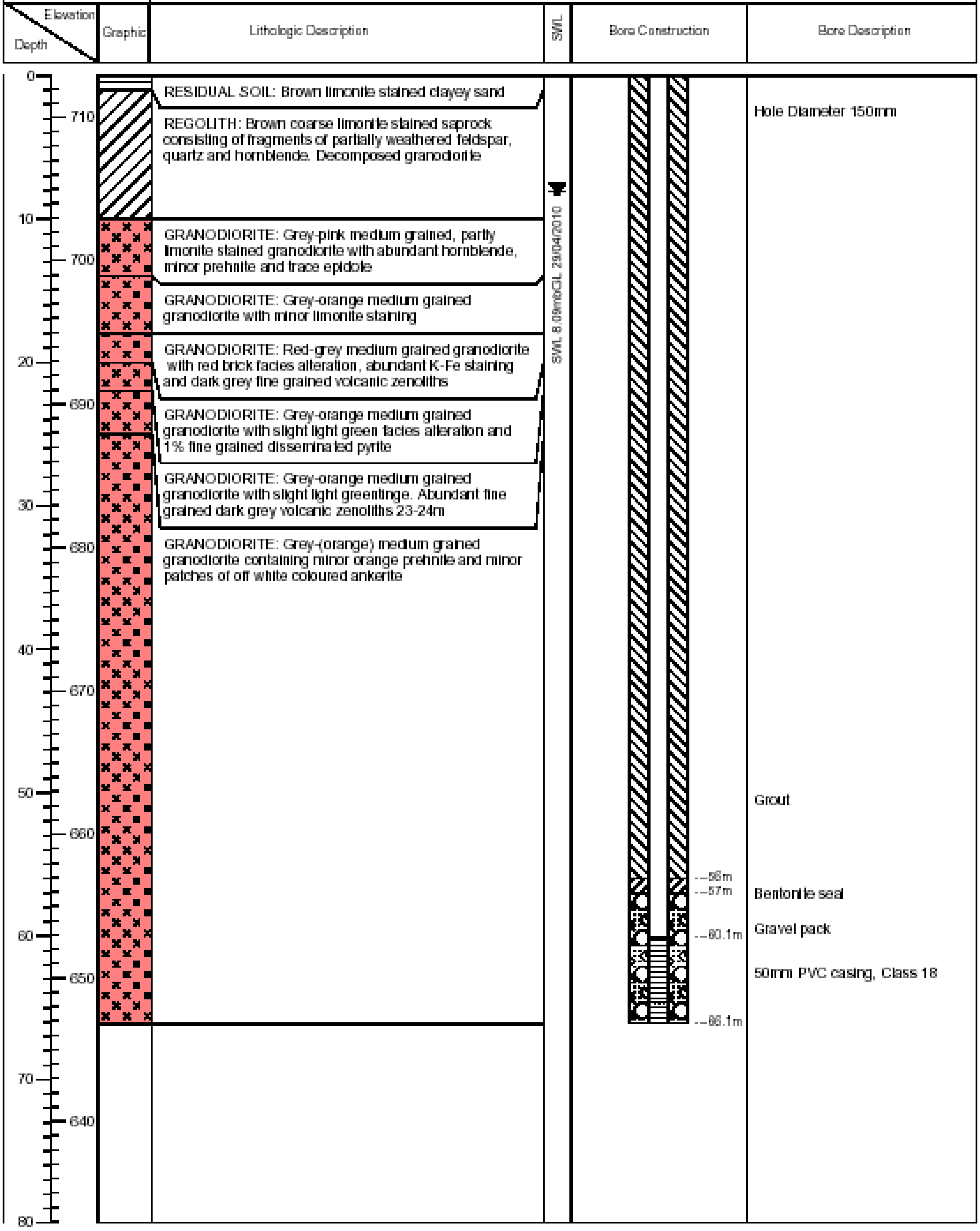
36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: DRWB03 Page 1 of 1

PROJECT NO.	G1494	DRILLER:	Danny Hill	DATUM:	MGA GDA94
PROJECT NAME:	Dargues Reef Gold Project	DRILLING METHOD:	RAB	GROUND LEVEL:	712.349m
DATE:	13/04/2010	DRILL RIG:		TOP OF CASING LEVEL:	712.909m
CONTRACTOR:	Bungendore Water Bores	COORDINATES:	749111.8 mE; 6063817.0 mN	LOGGED BY:	CS



RESIDUAL SOIL: Brown limonite stained clayey sand

REGOLITH: Brown coarse limonite stained saprock consisting of fragments of partially weathered feldspar, quartz and hornblende. Decomposed granodiorite

GRANODIORITE: Grey-pink medium grained, partly limonite stained granodiorite with abundant hornblende, minor prehnite and trace epidote

GRANODIORITE: Grey-orange medium grained granodiorite with minor limonite staining

GRANODIORITE: Red-grey medium grained granodiorite with red brick facies alteration, abundant K-Fe staining and dark grey fine grained volcanic zenoliths

GRANODIORITE: Grey-orange medium grained granodiorite with slight light green facies alteration and 1% fine grained disseminated pyrite

GRANODIORITE: Grey-orange medium grained granodiorite with slight light greentinge. Abundant fine grained dark grey volcanic zenoliths 23-24m

GRANODIORITE: Grey-(orange) medium grained granodiorite containing minor orange prehnite and minor patches of off white coloured ankerite

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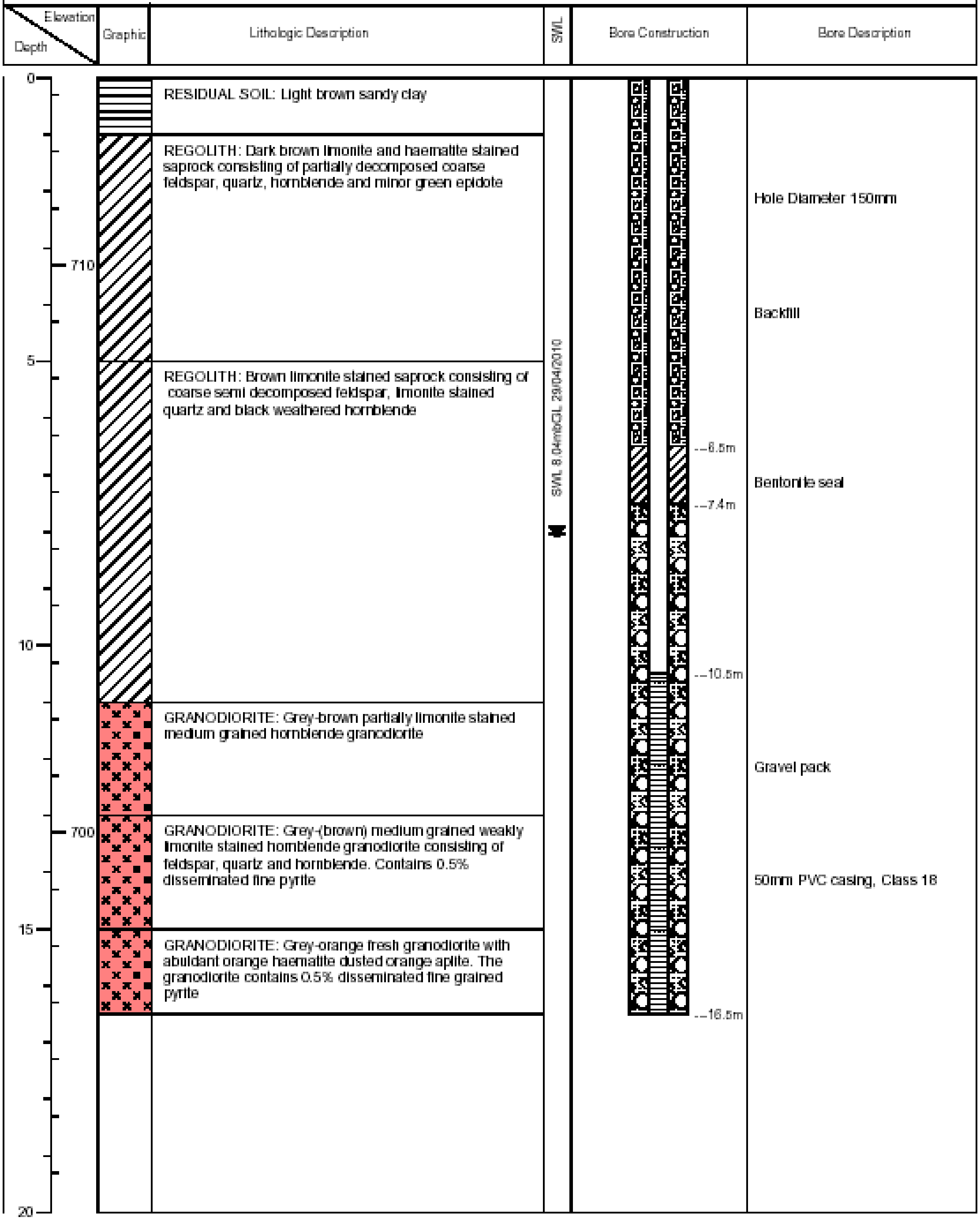
36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: DRWB04 Page 1 of 1

PROJECT NO.	G1494	DRILLER:	Danny Hill	DATUM:	MGA GDA94
PROJECT NAME:	Dargues Reef Gold Project	DRILLING METHOD:	RAB	GROUND LEVEL:	712.722m
DATE:	13/04/2010	DRILL RIG:		TOP OF CASING LEVEL:	713.292m
CONTRACTOR:	Bungendore Water Bores	COORDINATES:	749115.8 mE; 6063814.0 mN	LOGGED BY:	CS



RESIDUAL SOIL: Light brown sandy clay

REGOLITH: Dark brown limonite and haematite stained saprock consisting of partially decomposed coarse feldspar, quartz, hornblende and minor green epidote

REGOLITH: Brown limonite stained saprock consisting of coarse semi decomposed feldspar, limonite stained quartz and black weathered hornblende

GRANODIORITE: Grey-brown partially limonite stained medium grained hornblende granodiorite

GRANODIORITE: Grey-(brown) medium grained weakly limonite stained hornblende granodiorite consisting of feldspar, quartz and hornblende. Contains 0.5% disseminated fine pyrite

GRANODIORITE: Grey-orange fresh granodiorite with abuldant orange haematite dusted orange aplite. The granodiorite contains 0.5% disseminated fine grained pyrite

Monitoring Bores DRWB01 (left) and DRWB02 (right)

Monitoring Bores DRWB03 (left) and DRWB04 (right)
Spring Creek in background with the Spring location about midway between the two bores

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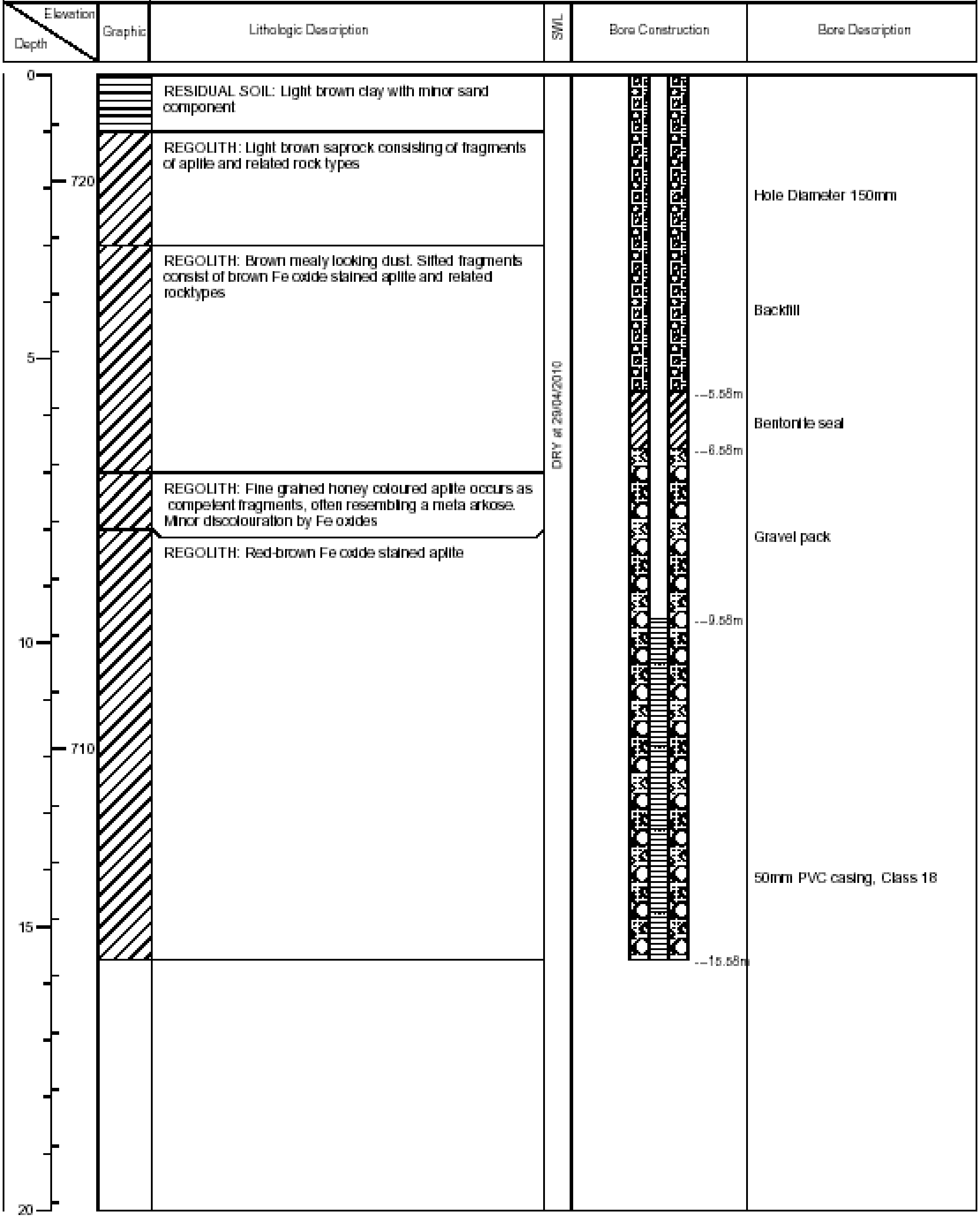
36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: DRWB05 Page 1 of 1

PROJECT NO.	G1494	DRILLER:	Danny Hill	DATUM:	MGA GDA94
PROJECT NAME:	Dargues Reef Gold Project	DRILLING METHOD:	RAB	GROUND LEVEL:	721.868m
DATE:	14/04/2010	DRILL RIG:		TOP OF CASING LEVEL:	721.268m
CONTRACTOR:	Bungendore Water Bores	COORDINATES:	749200.3 mE; 6063531.0 mN	LOGGED BY:	CS



RESIDUAL SOIL: Light brown clay with minor sand component

REGOLITH: Light brown saprock consisting of fragments of aplite and related rock types

REGOLITH: Brown mealy looking dust. Sifted fragments consist of brown Fe oxide stained aplite and related rocktypes

REGOLITH: Fine grained honey coloured aplite occurs as competent fragments, often resembling a meta arkose. Minor discolouration by Fe oxides

REGOLITH: Red-brown Fe oxide stained aplite

Hole Diameter 150mm

Backfill

Bentonite seal

Gravel pack

50mm PVC casing, Class 18

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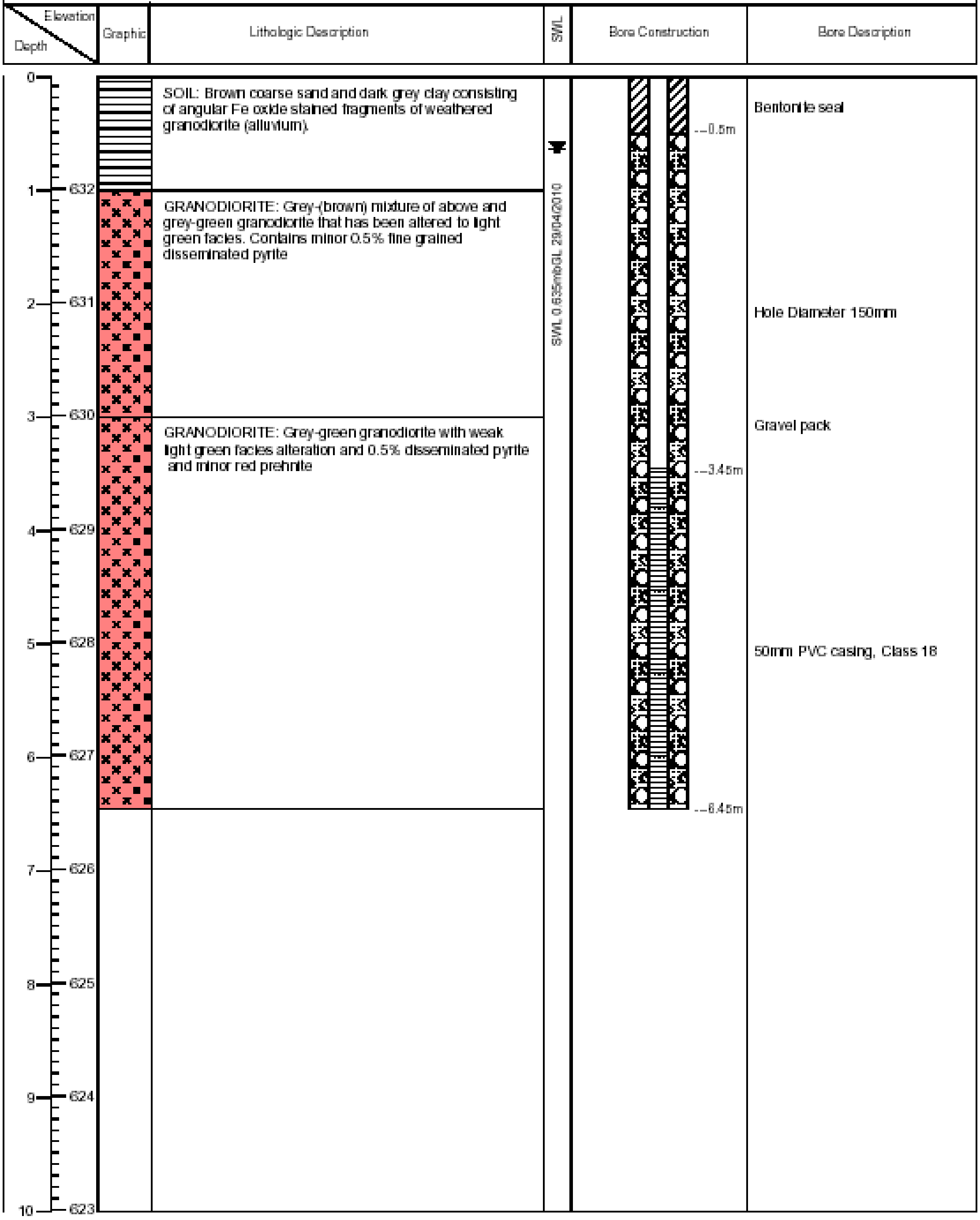
36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: DRWB06 Page 1 of 1

PROJECT NO.	G1494	DRILLER:	Danny Hill	DATUM:	MGA GDA94
PROJECT NAME:	Dargues Reef Gold Project	DRILLING METHOD:	RAB	GROUND LEVEL:	632.377m
DATE:	14/04/2010	DRILL RIG:		TOP OF CASING LEVEL:	632.982m
CONTRACTOR:	Bungendore Water Bores	COORDINATES:	748848.7 mE; 6061995 mN	LOGGED BY:	CS



SOIL: Brown coarse sand and dark grey clay consisting of angular Fe oxide stained fragments of weathered granodiorite (alluvium).

GRANODIORITE: Grey-(brown) mixture of above and grey-green granodiorite that has been altered to light green facies. Contains minor 0.5% fine grained disseminated pyrite

GRANODIORITE: Grey-green granodiorite with weak light green facies alteration and 0.5% disseminated pyrite and minor red prehnite

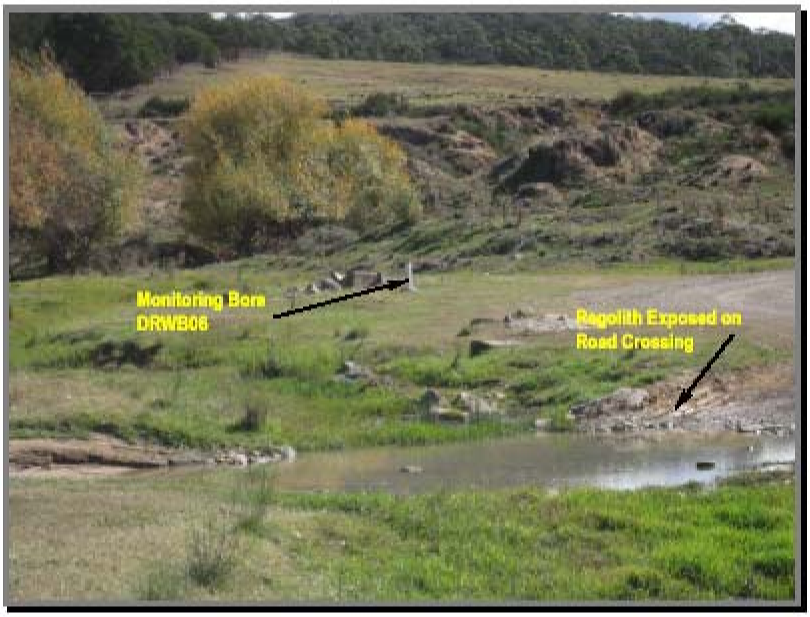
Bentonite seal

Hole Diameter 150mm

Gravel pack

50mm PVC casing, Class 18

Monitoring Bores DRWB05



Monitoring Bores DRWB06 in Alluvium of Majors Creek

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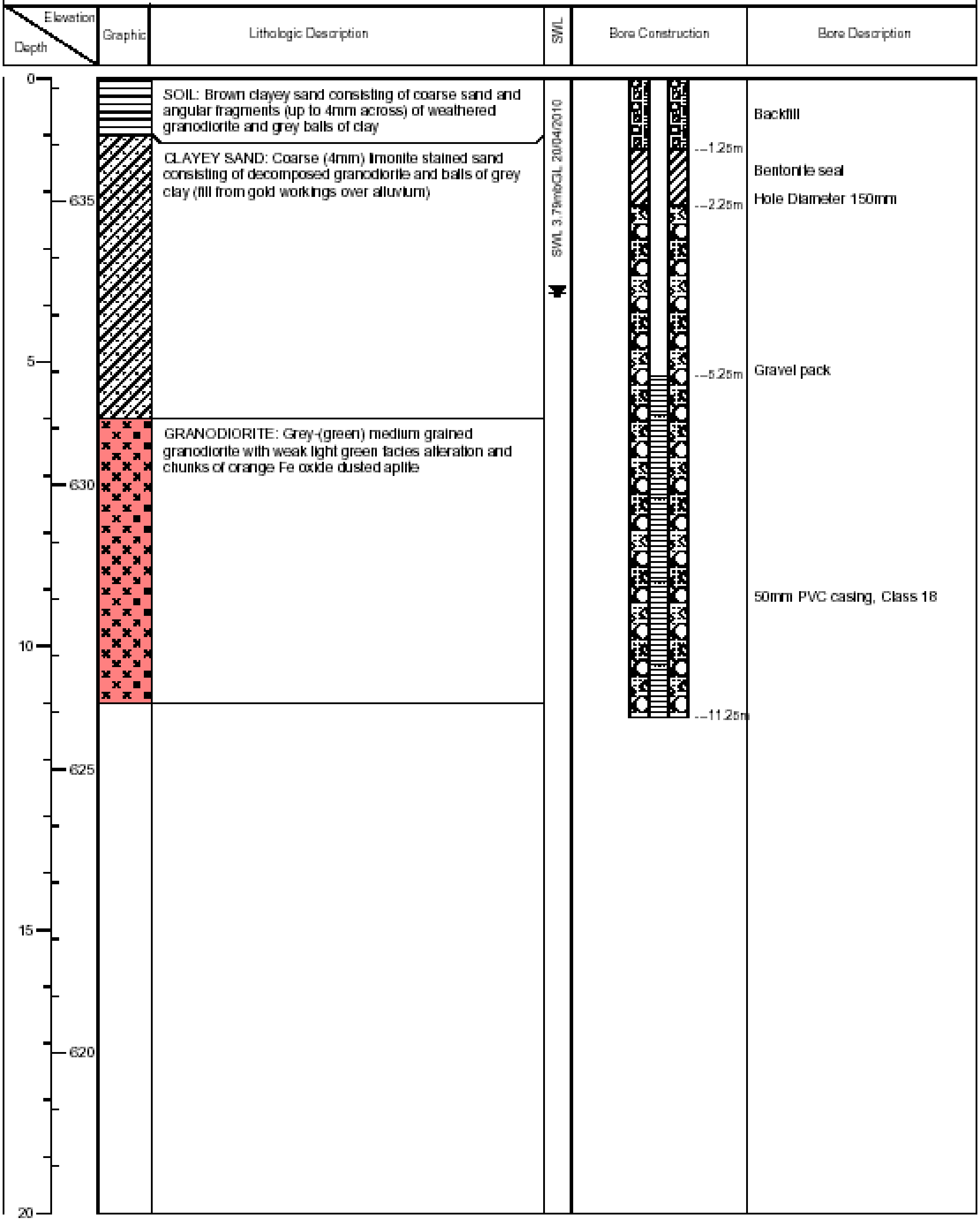
36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **DRWB07** Page 1 of 1

PROJECT NO.	G1494	DRILLER:	Danny Hill	DATUM:	MGA GDA94
PROJECT NAME:	Dargues Reef Gold Project	DRILLING METHOD:	RAB	GROUND LEVEL:	636.719m
DATE:	14/04/2010	DRILL RIG:		TOP OF CASING LEVEL:	637.169m
CONTRACTOR:	Bungendore Water Bores	COORDINATES:	748724.7 mE; 6061835 mN	LOGGED BY:	CS



SOIL: Brown clayey sand consisting of coarse sand and angular fragments (up to 4mm across) of weathered granodiorite and grey balls of clay

CLAYEY SAND: Coarse (4mm) limonite stained sand consisting of decomposed granodiorite and balls of grey clay (fill from gold workings over alluvium)

GRANODIORITE: Grey-(green) medium grained granodiorite with weak light green facies alteration and chunks of orange Fe oxide dusted aplite

Backfill

Bentonite seal

Hole Diameter 150mm

Gravel pack

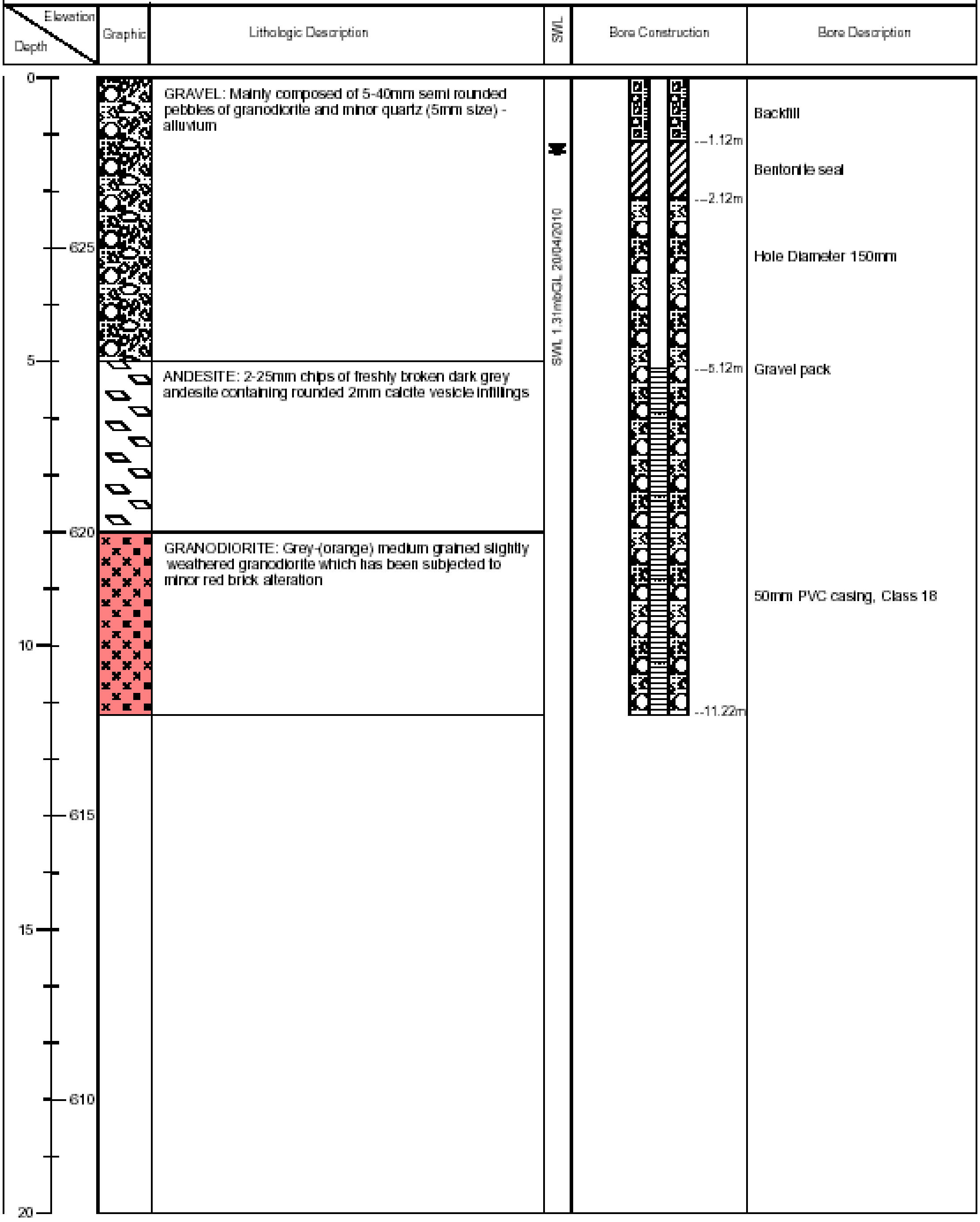
50mm PVC casing, Class 18

Australasian Groundwater & Environmental Consultants Pty Ltd
36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: DRWB08 Page 1 of 1

PROJECT NO.	G1494	DRILLER:	Danny Hill	DATUM:	MGA GDA94
PROJECT NAME:	Dargues Reef Gold Project	DRILLING METHOD:	RAB	GROUND LEVEL:	627.385m
DATE:	14/04/2010	DRILL RIG:		TOP OF CASING LEVEL:	628.005m
CONTRACTOR:	Bungendore Water Bores	COORDINATES:	749240.0 mE; 6061796.0 mN	LOGGED BY:	CS



GRAVEL: Mainly composed of 5-40mm semi rounded pebbles of granodiorite and minor quartz (5mm size) - alluvium

ANDESITE: 2-25mm chips of freshly broken dark grey andesite containing rounded 2mm calcite vesicle infillings

GRANODIORITE: Grey-(orange) medium grained slightly weathered granodiorite which has been subjected to minor red brick alteration

Monitoring Bores DRWB07 on Mullock Heap of Reworked Alluvium – Majors Creek

Monitoring Bores DRWB08 - Alluvium Downstream on Majors Creek

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Appendix 3

Permeability Test Analyses

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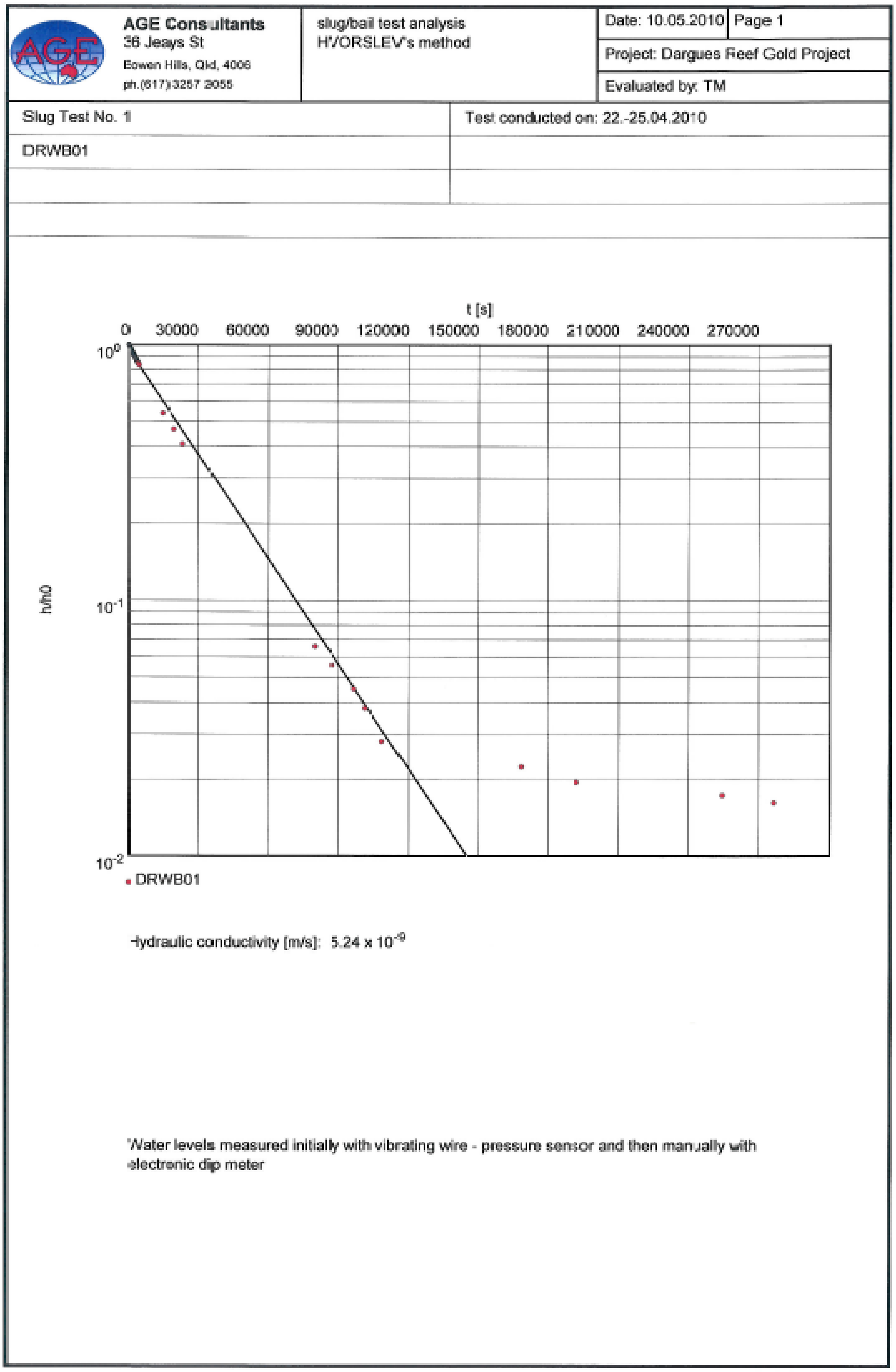


AGE Consultants
36 Jeays St
Bowen Hills, Qld, 4006
ph.(617) 3257 2055

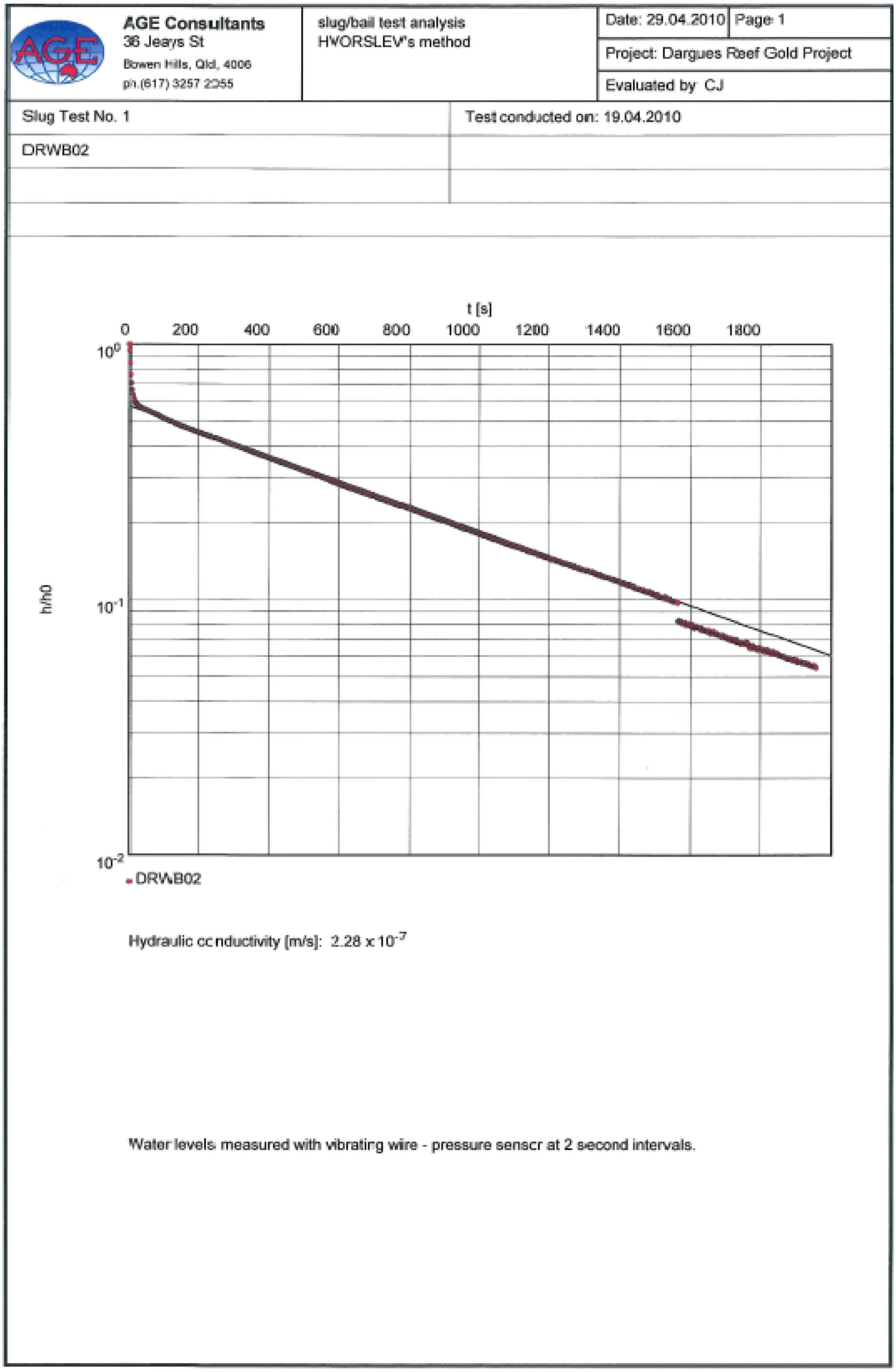
slug/bail test analysis
HVORSLEV's method

Date: 10.05.2010	Page 1
Project: Dargues Reef Gold Project	
Evaluated by: TM	

Slug Test No. 1	Test conducted on: 22.-25.04.2010
DRWB01	

Hydraulic conductivity [m/s]: 5.24 x 10^{-9}

Water levels measured initially with vibrating wire - pressure sensor and then manually with electronic dip meter



AGE Consultants
36 Jeays St
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ph.(617) 3257 2055

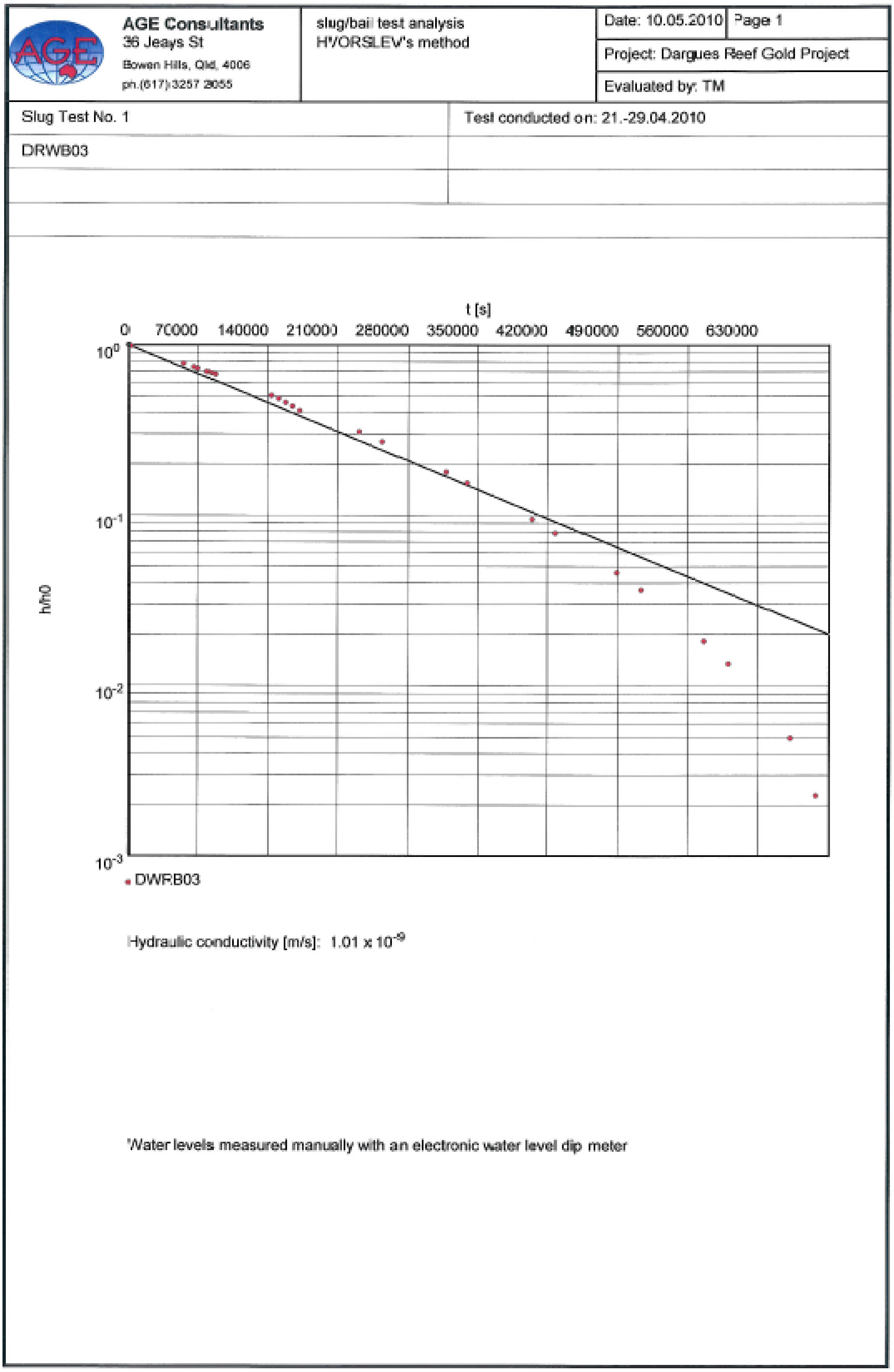
slug/bail test analysis
HVORSLEV's method

Date: 29.04.2010
Page 1
Project: Dargues Reef Gold Project
Evaluated by: CJ

Slug Test No. 1
Test conducted on: 19.04.2010
DRWB02

Hydraulic conductivity [m/s]: 2.28×10^{-7}

Water levels measured with vibrating wire - pressure sensor at 2 second intervals.



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ph.(617) 3257 2055

slug/bail test analysis
HVORSLEV's method

Date: 10.05.2010 Page 1

Project: Dargues Reef Gold Project

Evaluated by: TM

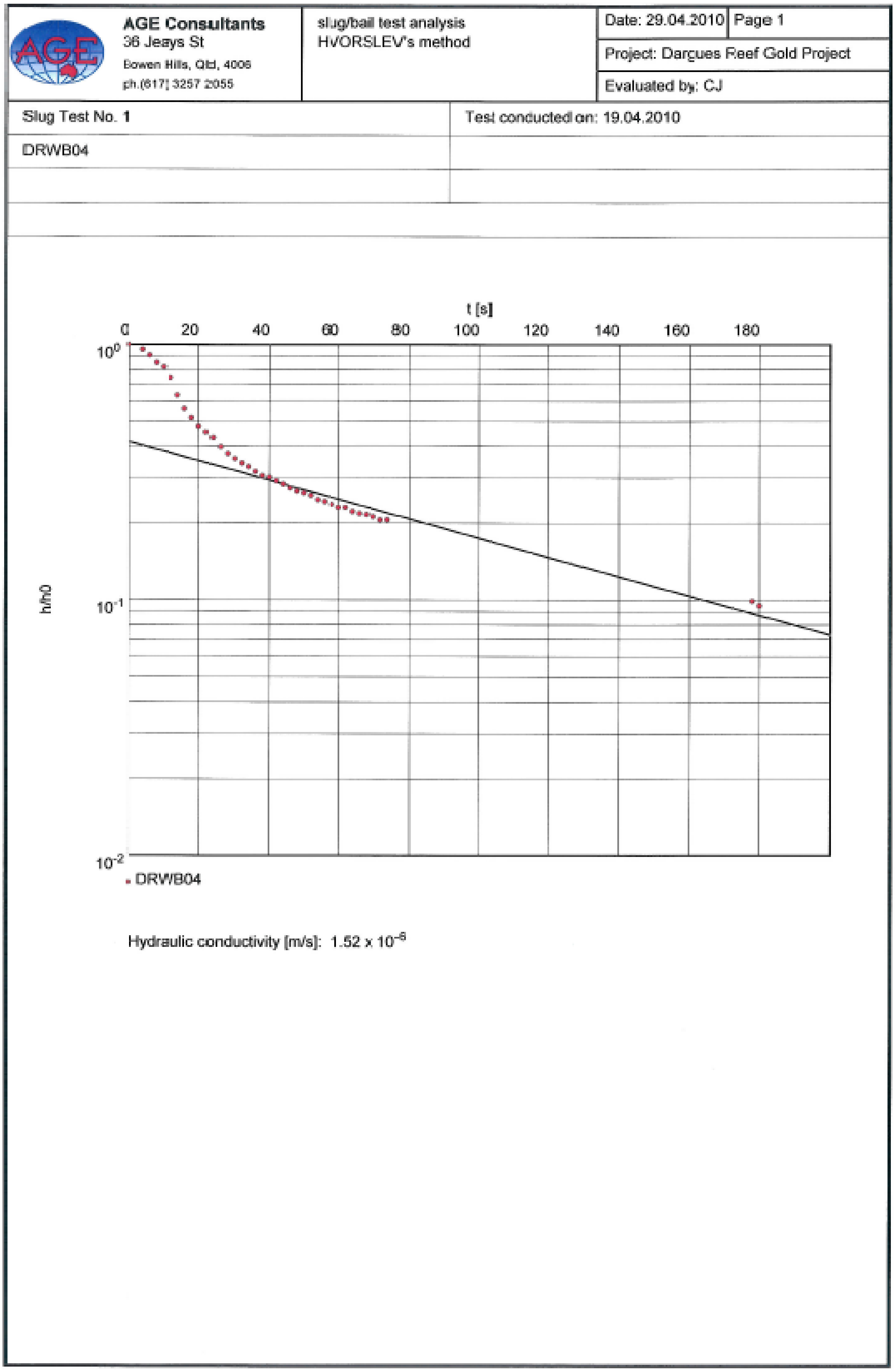
Slug Test No. 1

Test conducted on: 21.-29.04.2010

DRWB03

Hydraulic conductivity [m/s]: 1.01×10^{-9}

Water levels measured manually with an electronic water level dip meter



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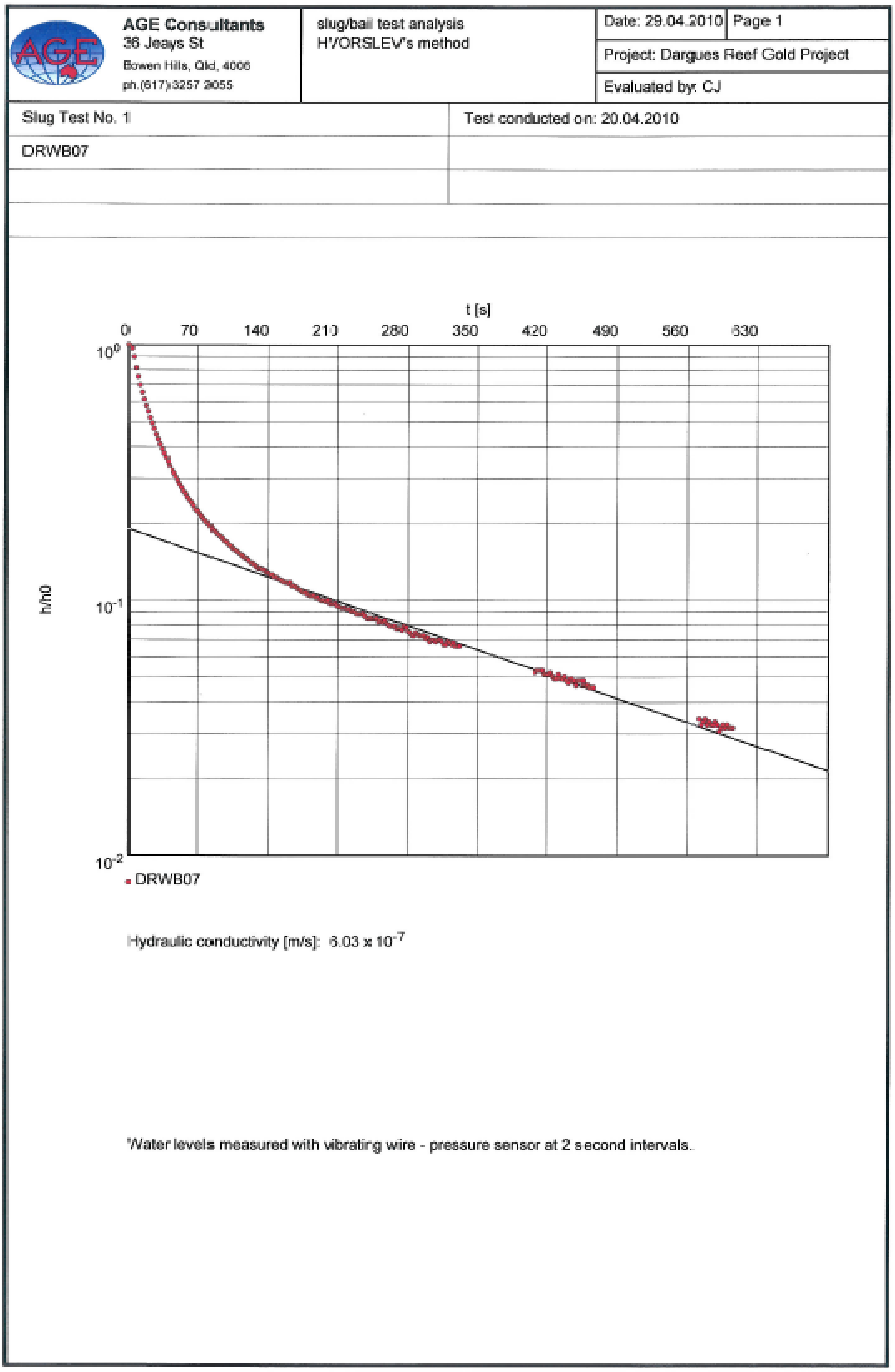
slug/bail test analysis
HVORSLEV's method

Date: 29.04.2010
Page 1
Project: Dargues Reef Gold Project
Evaluated by: CJ

Slug Test No. 1
Test conducted on: 19.04.2010
DRWB04

Hydraulic conductivity [m/s]: 1.52×10^{-6}



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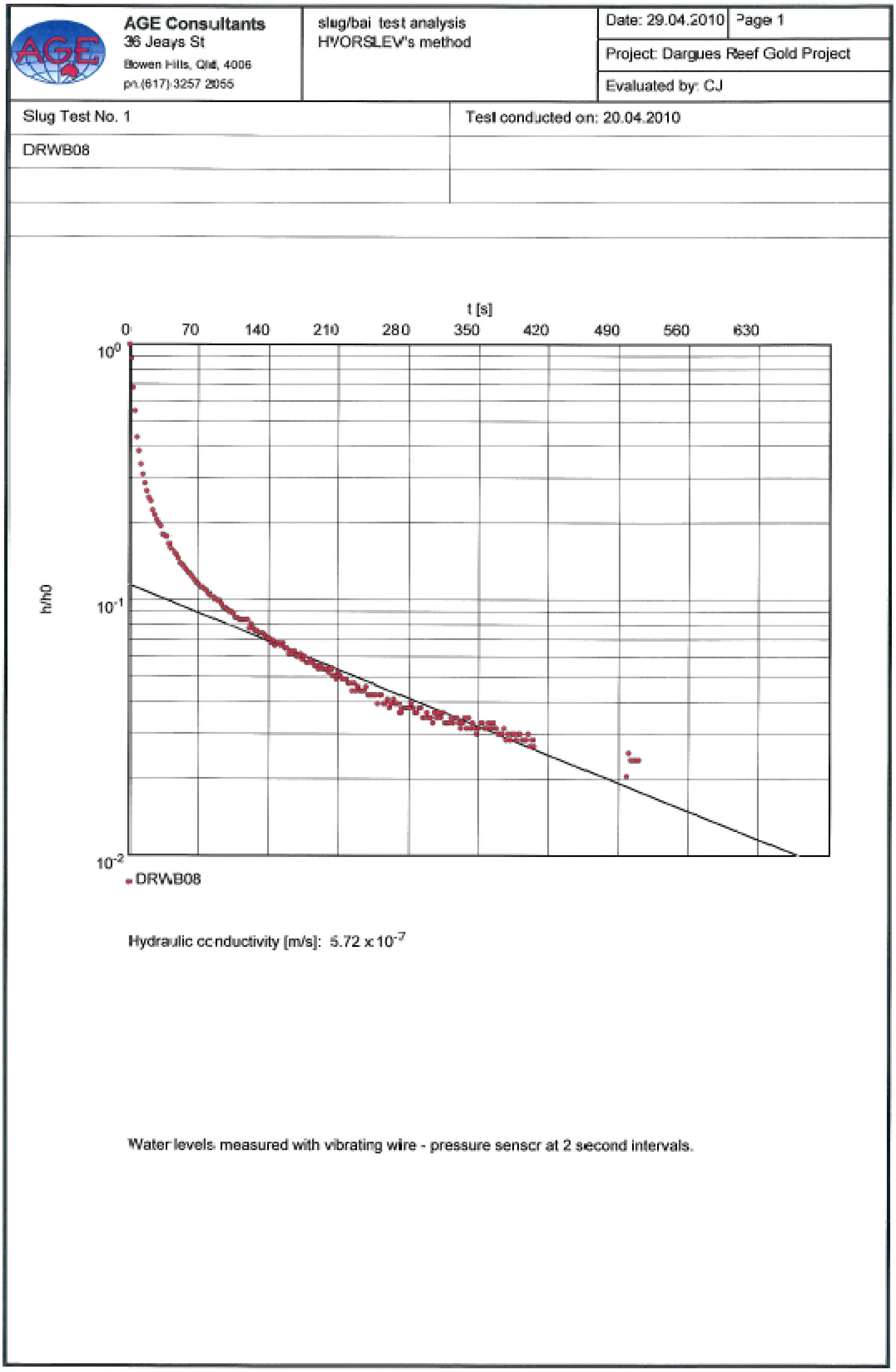
slug/bail test analysis
HVORSLEV's method

Date: 29.04.2010
Page 1
Project: Dargues Reef Gold Project
Evaluated by: CJ

Slug Test No. 1
Test conducted on: 20.04.2010
DRWB07

Hydraulic conductivity [m/s]: 6.03 x 10^{-7}

Water levels measured with vibrating wire - pressure sensor at 2 second intervals.



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slug/bail test analysis
HVORSLEV's method

Date: 29.04.2010 Page 1
Project: Dargues Reef Gold Project
Evaluated by: CJ

Slug Test No. 1 Test conducted on: 20.04.2010
DRWB08

Hydraulic conductivity [m/s]: 5.72×10^{-7}

Water levels measured with vibrating wire - pressure sensor at 2 second intervals.

Appendix 4

Bore – Well Census Data

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BORE - WELL CENSUS DATA

Bore/Well	mE	mN	RLm	Owner	Address	Details	Comment
1	748435	6060550	680	Callan	Araluen St	bore & well (see data sheet)	hard water, clear
2	748390	6060533	680	Callan	Araluen St	well (see data sheet)	not used
3	748195	6059922	699	Beltrami	Hill St	bore (see data sheet)	good water
4	748198	6060333		Arno & Nell Strezina	Seymour St	bore (see data sheet)	
5	748624	6060500	703	McKenzie	Hill St	bore (see data sheet)	good soft water
6	750840	6063571	699	James Royds	Durham Hall	bore (see data sheet)	new bore, drilled by Bungendore Waterbores - steel & PVC casing, no pump, capped, water level unknown
7	748522	6060191	692	Frank & Penny Hardy	King st	bore, PVC case, 700mm stick up	
8	748886	6060359	699	Randall & Marjorie Lemin	7 Wilson St	bore pvc case	
9	748966	6060211	693	Unknown owner	10-12 Wilson st	steel 6" casing, 300mm stick up	elec submersible
10	748704	6060392	696	unknown owner (old Catholic Church)	3 Wilson St	6" steel casing, 450mm stick up	no pump, water level approx 30m down,
11	748158	6060638	679	Majors Crk Hotel.	Cnr Seymour & George St	bore	no longer used
12	748436	6060622	684	M & S McCarron	Araluen St (old police stn)	bore, 1992, 47m deep	used to give good water, but now not much good (volume)
13	749072	6060767	679	unknown Owner	Burke St		
14	748539	6060532	690	unknown Owner	Hill St, next to St Stephens Church		disused

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BORE - WELL CENSUS DATA

Bore/Well	mE	mN	RLm	Owner	Address	Details	Comment
15	746917	6061149	718	Victor Crandell	near Long Flat reserve	well	lines with conc pipe, water visible at ~4.5m
16	747691	6063137	698	Owen Gwynn	Exeter Farm	well, ~900mm across	source of Shingle Hut Crk, old stone lined well, water visible at 0.4m, fenced from stock
17	747654	6063711	707	Owen Gwynn	Exeter Farm	well, ~1700mm across	old stone lined well , water visible at 0.7m, fenced
18	749290	6065175	696	Owen Gwynn	Exeter Farm	bore (see data sheet)	new bore, solar powered submersible pump, stock use
19	748713	6066305	670	Owen Gwynn	Exeter Farm	bore (see data sheet)	new bore approx 200m west of house, domestic use
20	749632	6065221	691	Owen Gwynn	Exeter Farm	well	old stone and concrete well, water level 0.4mbGL , stock water
21	750016	6065564	681	James Royds	Durham Hall	well, 1.9m diam	old stone well, east side of house, dry since 1990
22	750202	6065748	672	James Royds	Durham Hall	well, 1.1m diam, depth approx 10m	old stone well approx 250m NNE of house, domestic and stock water, windmill powered, 500L/hr, water level 1.8m below ground
23	751029	6065117	677	Antony Davies	MillPond Farm	well, 0.85m diam.	old brick lined well, south end of house, not used at present. water level 2.7m below ground
24	750975	6065271	674	Antony Davies	MillPond Farm	well, 0.75m diam	old stone well adjacent to flour mill, not used at present, water level 1.3m below ground
25	751116	6064962	678	Antony Davies	MillPond Farm	well, 1.9m diam	old stone well approx 250m SE of house, windmill powered, domestic use, water level 0.8m below ground

PROPERTY NAME	***Misery Farm***	***Misery Farm***		
Land Owner	**Peter Callan**	**Peter Callan**	**Luciana Beltrami**	**N & A Strezina**
NOW Registered Number				
Number/ Type	**1** - bore	**2** - well	**3**	**4** - bore
Bore Location	Araluen St, Majors Crk. rear of house	front of house	Hill St Majors Crk. 50m nth of house	Seymour St
Easting (datum projection)	748435	748390	748195	748198
Northing	6060650	6060533	6059922	6060333
RL	680	680	699	
Stick up of Casing (m)	0.32		0.7m	
CONSTRUCTION				
Year Drilled	c 1985	unknown	c 1992	approx 15 Yrs ago
Total Drilled Depth (m)			approx 30m	approx 20m
Casing Type	steel	stones	steel	
Screen Type				
Top of Screen				
Bottom of Screen				
Bore Diametre	165mm OD	1300mm	165mm	150mm
Water Struck Depth	4.2m	4.2m		
STRATIGRAPHY				
NOW Log Available				
Owners Log Available				600mm soil, sand, conglomerate, granite. Touched hard granite at 20m
Water Bed Details				
WATER LEVEL				
Water Depth Below Ref	2.75m	4.2m	est 25-30m	
Date of Measurement	27/05/2010	27/05/2010	28/05/2010	
Description of Ref	top of casing	ground level	top of casing	
Height of Ref. aGL			0.7m	
PUMPING DETAILS				
Bore in Use	yes	no	yes	yes
Pumping Equipment	domestic pressure pump		onga domestic pressure pump	domestic pump
Power Supply	240v		240v	240v
Pump Suction Setting				
Pumping Rate				
Daily Pumping Period			3-4 hrs/ 3 weeks	
WATER USAGE				
Primary Use of Bore	domestic		domestic	domestic
No. Stock on Bore				
Land Irrigated				
DISTRIBUTION				
Storage Type	tank		tank	
No. Of Troughs				
Trough Description				
WATER QUALITY				
pH				
Electrical Conductivity				
COMMENTS				
Comments	owner said water is clear but hard. Soap does not lather	well covered with timber, not used	owner said the water is very good, whole house runs on it, drinking too.	runs 3 hoses, doesn't run dry. Silted up to 14.6m
CENSUS DETAILS				
Completed by	Brian James	Brian James	Brian James	Greg Cozens
Date	27/05/2010	27/05/2010	28/05/2010	13/05/2010

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PROPERTY NAME	*Pinehurst*	*Durham Hall*	*Exeter farm*	*Exeter farm*
Land Owner	**Ray McKenzie**	**James Royds**	**Owen Gwynn**	**Owen Gwynn**
NOW Registered Number	10BL156474			
Number/ Type	**5**	**6** - new bore	**18** - bore	**19** - bore
Bore Location	Hill St Majors Crk			
Easting (datum projection)	748624	750840	749290	748713
Northing	6060600	6063571	6065175	6066305
RL	703	699	698	670
Stick up of Casing (m)	0.3m			600mm
CONSTRUCTION				
Year Drilled	1992	2010	2009	2009
Total Drilled Depth (m)	100ft		30m	36m
Casing Type	PVC	steel & PVC	steel & PVC	150mm steel
Screen Type				
Top of Screen	40ft			
Bottom of Screen	80ft			
Bore Diametre	150mm		150mm	
Water Struck Depth	60ft			
STRATIGRAPHY				
NOW Log Available				
Owners Log Available				
Water Bed Details			fractures	fractures
WATER LEVEL				
Water Depth Below Ref.				
Date of Measurement				
Description of Ref.				
Height of Ref. aGL				
PUMPING DETAILS				
Bore in Use	yes		yes	yes
Pumping Equipment	Davey pressure pump	no pump fitted	submersible pump	pressure pump
Power Supply	elect		solar	240v
Pump Suction Setting				
Pumping Rate			700 gal/hr	700 gal/hr
Daily Pumping Period				
WATER USAGE				
Primary Use of Bore	domestic		stock	domestic
No. Stock on Bore				
Land Irrigated				
DISTRIBUTION				
Storage Type			tank	
No. Of Troughs				
Trough Description				
WATER QUALITY	Good			
pH				
Electrical Conductivity			good water	
COMMENTS				
Comments	easy soap lather, very clean & soft	drilled by Bungendore Waterbores (Danny Hill)	drilled by Bungendore Waterbores (Danny Hill)	drilled by Bungendore Waterbores (Danny Hill)
CENSUS DETAILS				
Completed by	Brian James	Brian James	Brian James	Brian James
Date	1/06/2010	2/06/2010	21/07/2010	21/07/2010

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Appendix 5

Water Level Data

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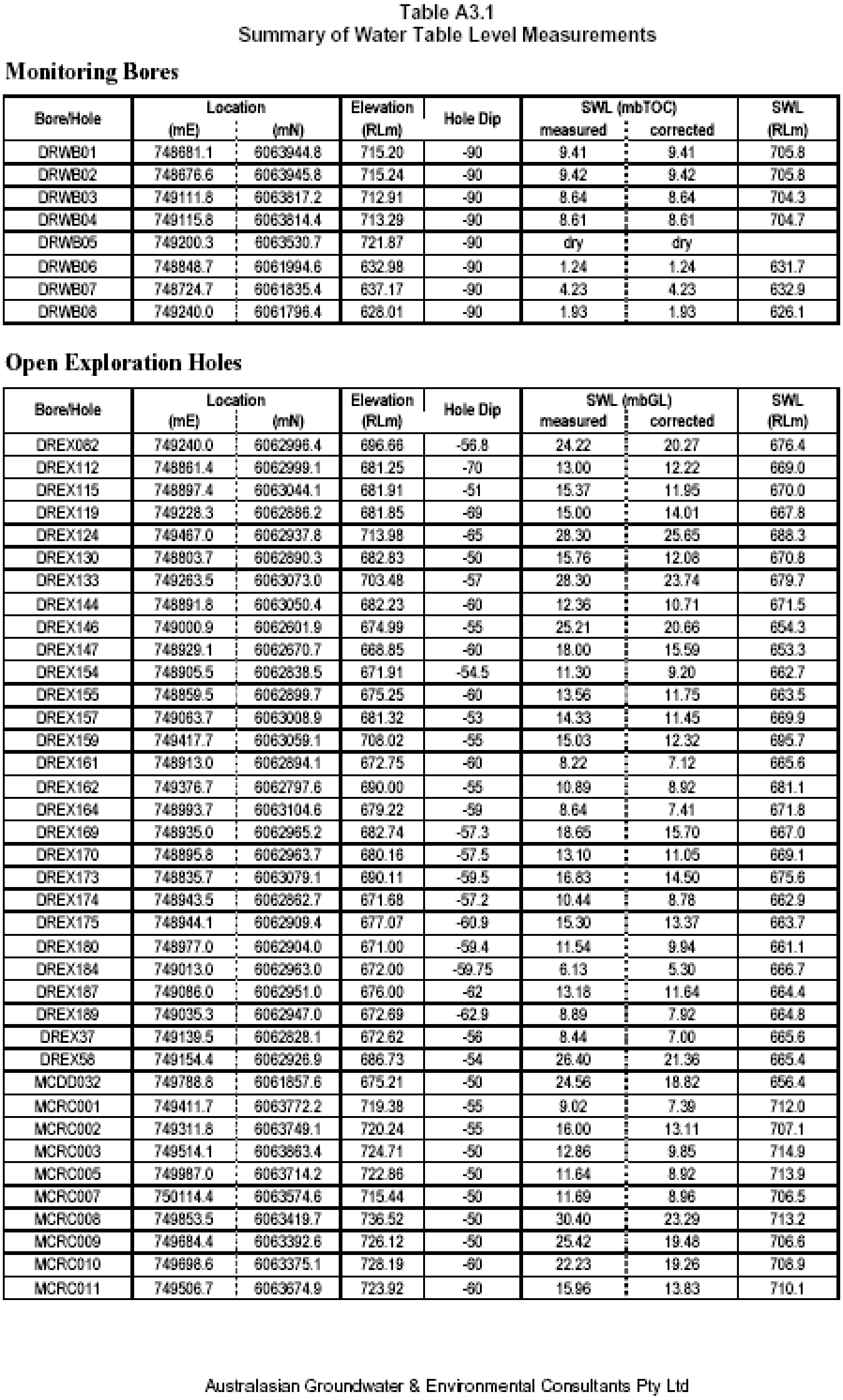

Table A3.1
Summary of Water Table Level Measurements

Monitoring Bores

Bore/Hole	Location		Elevation	Hole Dip	SWL (mbTOC)		SWL
	(mE)	(mN)	(RLm)		measured	corrected	(RLm)
DRWB01	748681.1	6063944.8	715.20	-90	9.41	9.41	705.8
DRWB02	748676.6	6063945.8	715.24	-90	9.42	9.42	705.8
DRWB03	749111.8	6063817.2	712.91	-90	8.64	8.64	704.3
DRWB04	749115.8	6063814.4	713.29	-90	8.61	8.61	704.7
DRWB05	749200.3	6063530.7	721.87	-90	dry	dry	
DRWB06	748848.7	6061994.6	632.98	-90	1.24	1.24	631.7
DRWB07	748724.7	6061835.4	637.17	-90	4.23	4.23	632.9
DRWB08	749240.0	6061796.4	628.01	-90	1.93	1.93	626.1

Open Exploration Holes

Bore/Hole	Location		Elevation	Hole Dip	SWL (mbGL)		SWL
	(mE)	(mN)	(RLm)		measured	corrected	(RLm)
DREX082	749240.0	6062996.4	696.66	-56.8	24.22	20.27	676.4
DREX112	748861.4	6062999.1	681.25	-70	13.00	12.22	669.0
DREX115	748897.4	6063044.1	681.91	-51	15.37	11.95	670.0
DREX119	749228.3	6062886.2	681.85	-69	15.00	14.01	667.8
DREX124	749467.0	6062937.8	713.98	-65	28.30	25.65	688.3
DREX130	748803.7	6062890.3	682.83	-50	15.76	12.08	670.8
DREX133	749263.5	6063073.0	703.48	-57	28.30	23.74	679.7
DREX144	748891.8	6063050.4	682.23	-60	12.36	10.71	671.5
DREX146	749000.9	6062601.9	674.99	-55	25.21	20.66	654.3
DREX147	748929.1	6062670.7	668.85	-60	18.00	15.59	653.3
DREX154	748905.5	6062838.5	671.91	-54.5	11.30	9.20	662.7
DREX155	748859.5	6062899.7	675.25	-60	13.56	11.75	663.5
DREX157	749063.7	6063008.9	681.32	-53	14.33	11.45	669.9
DREX159	749417.7	6063059.1	708.02	-55	15.03	12.32	695.7
DREX161	748913.0	6062894.1	672.75	-60	8.22	7.12	665.6
DREX162	749376.7	6062797.6	690.00	-55	10.89	8.92	681.1
DREX164	748993.7	6063104.6	679.22	-59	8.64	7.41	671.8
DREX169	748935.0	6062965.2	682.74	-57.3	18.65	15.70	667.0
DREX170	748895.8	6062963.7	680.16	-57.5	13.10	11.05	669.1
DREX173	748835.7	6063079.1	690.11	-59.5	16.83	14.50	675.6
DREX174	748943.5	6062862.7	671.68	-57.2	10.44	8.78	662.9
DREX175	748944.1	6062909.4	677.07	-60.9	15.30	13.37	663.7
DREX180	748977.0	6062904.0	671.00	-59.4	11.54	9.94	661.1
DREX184	749013.0	6062963.0	672.00	-59.75	6.13	5.30	666.7
DREX187	749086.0	6062951.0	676.00	-62	13.18	11.64	664.4
DREX189	749035.3	6062947.0	672.69	-62.9	8.89	7.92	664.8
DREX37	749139.5	6062828.1	672.62	-56	8.44	7.00	665.6
DREX58	749154.4	6062926.9	686.73	-54	26.40	21.36	665.4
MCDD032	749788.8	6061857.6	675.21	-50	24.56	18.82	656.4
MCRC001	749411.7	6063772.2	719.38	-55	9.02	7.39	712.0
MCRC002	749311.8	6063749.1	720.24	-55	16.00	13.11	707.1
MCRC003	749514.1	6063863.4	724.71	-50	12.86	9.85	714.9
MCRC005	749987.0	6063714.2	722.86	-50	11.64	8.92	713.9
MCRC007	750114.4	6063574.6	715.44	-50	11.69	8.96	706.5
MCRC008	749853.5	6063419.7	736.52	-50	30.40	23.29	713.2
MCRC009	749684.4	6063392.6	726.12	-50	25.42	19.48	706.6
MCRC010	749698.6	6063375.1	728.19	-60	22.23	19.26	708.9
MCRC011	749506.7	6063674.9	723.92	-60	15.96	13.83	710.1

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Bore/Hole	Location		Elevation	Hole Dip	SWL (mbGL)		SWL
	(mE)	(mN)	(RLm)		measured	corrected	(RLm)
MCRC015	749775.1	6061918.9	669.81	-60	17.81	15.43	654.4
MCRC018	749654.3	6061822.7	657.87	-55	22.67	18.58	639.3
MCRC019	748215.8	6062053.9	672.39	-55	14.19	11.63	660.8
MCRC020	748214.6	6062067.3	671.55	-55	13.17	10.79	660.8
MCRC021	748138.5	6062104.9	683.85	-54	9.81	7.94	675.9
MCRC022	748137.8	6062103.2	684.27	-54	25.50	20.64	663.6
MCRC023	748153.8	6062128.6	680.51	-59	21.82	18.71	661.8
MCRC024	748116.2	6062134.0	685.18	-53	18.93	15.12	670.1
MCRC025	748114.8	6062131.0	685.47	-60	20.85	18.06	667.4
MCRC026	748110.1	6062115.1	686.50	-60	16.07	13.92	672.6
MCRC027	748476.1	6061998.2	672.15	-66.7	23.94	21.99	650.2
MCRC028	748495.9	6061820.1	668.42	-65	26.16	23.71	644.7
MCRC029	748491.8	6061819.9	668.51	-55	28.49	23.34	645.2
MCRC030	748045.9	6061985.8	701.73	-62	37.73	33.32	668.4

Notes: i) SWL = static water level
ii) mbTOC = metres below top of casing
iii) corrected = SWL corrected for the angle (dip) of the hole

Appendix 6

Drawdown and Recovery Contours – Years 1-8

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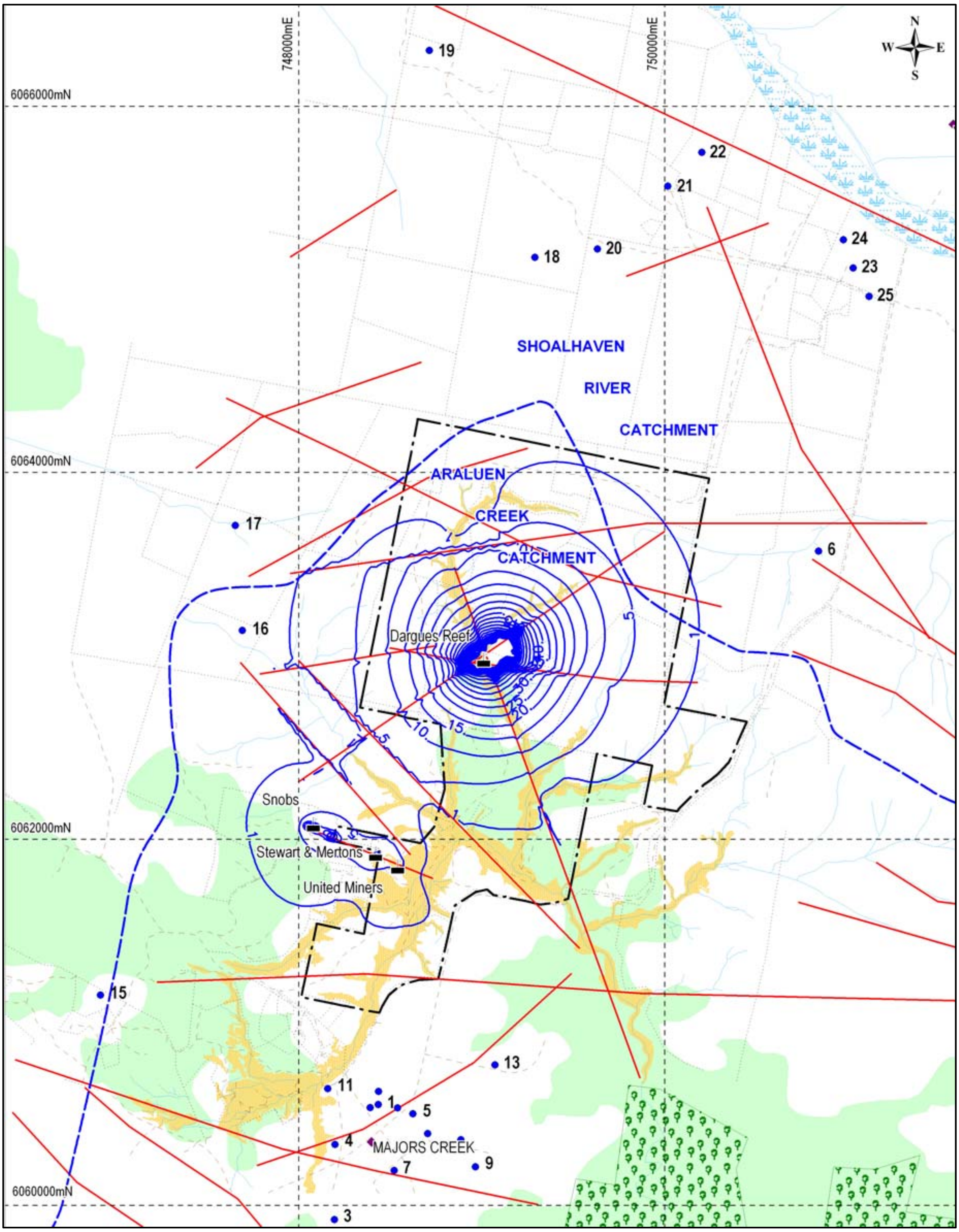
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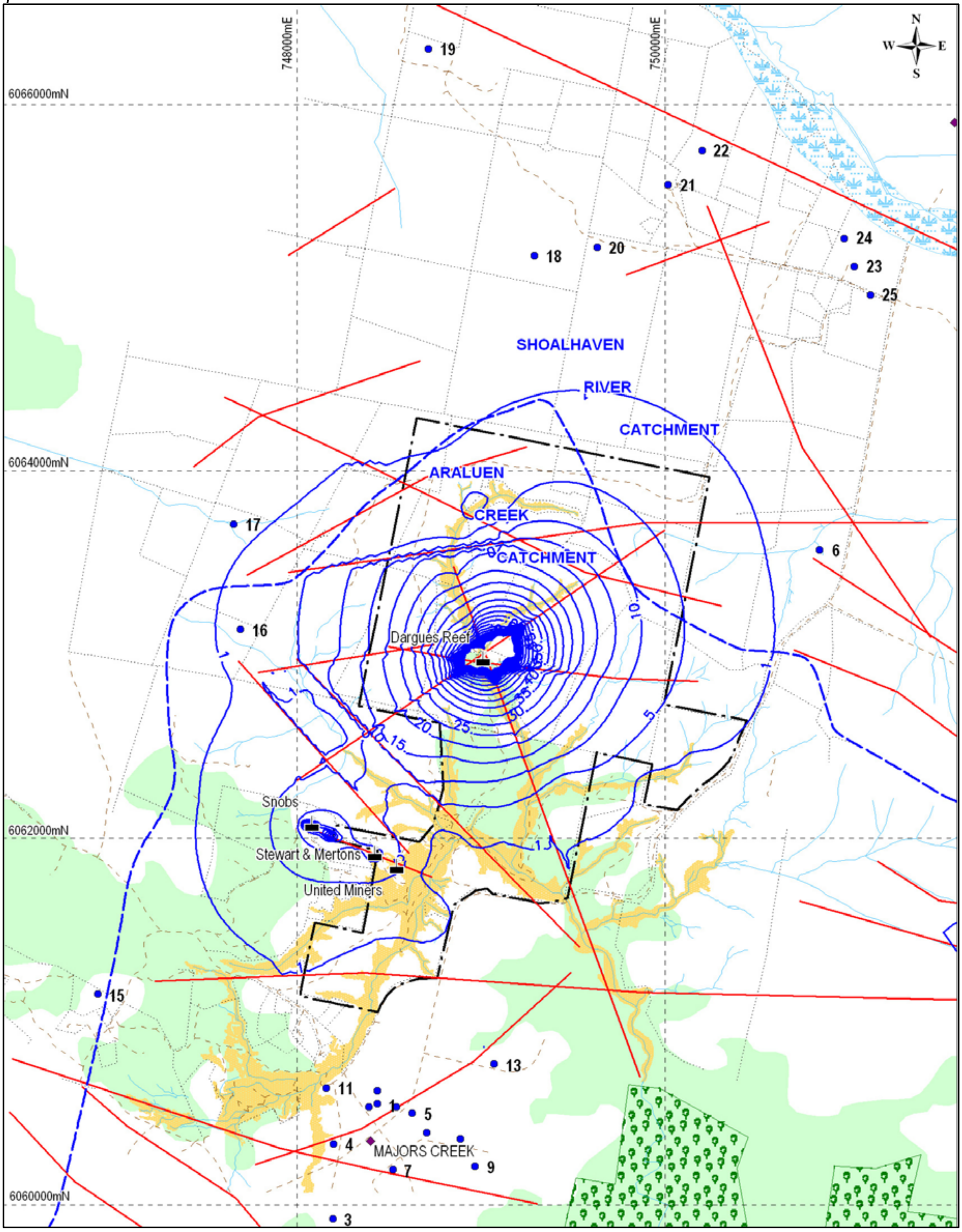
Year 1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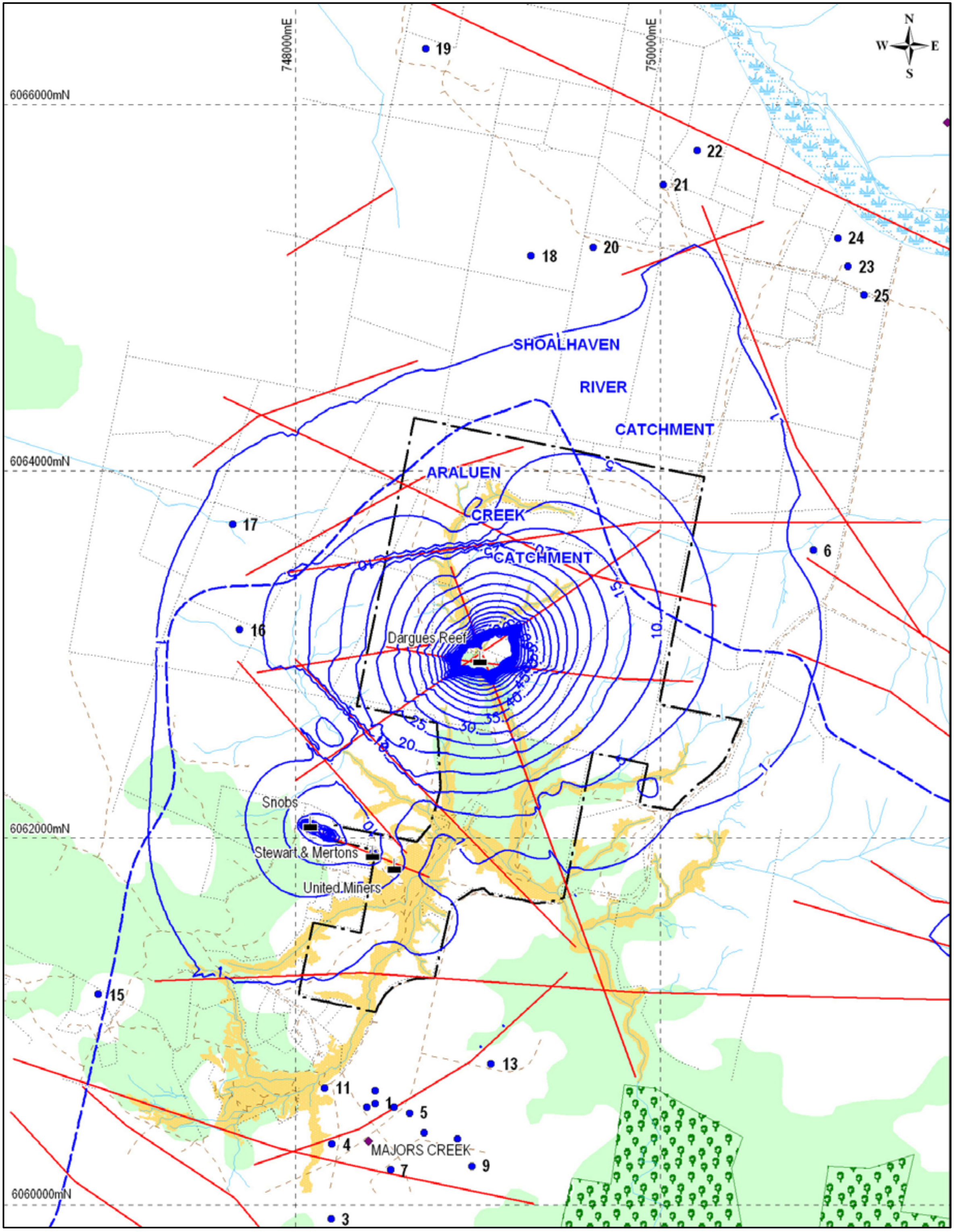
Year 2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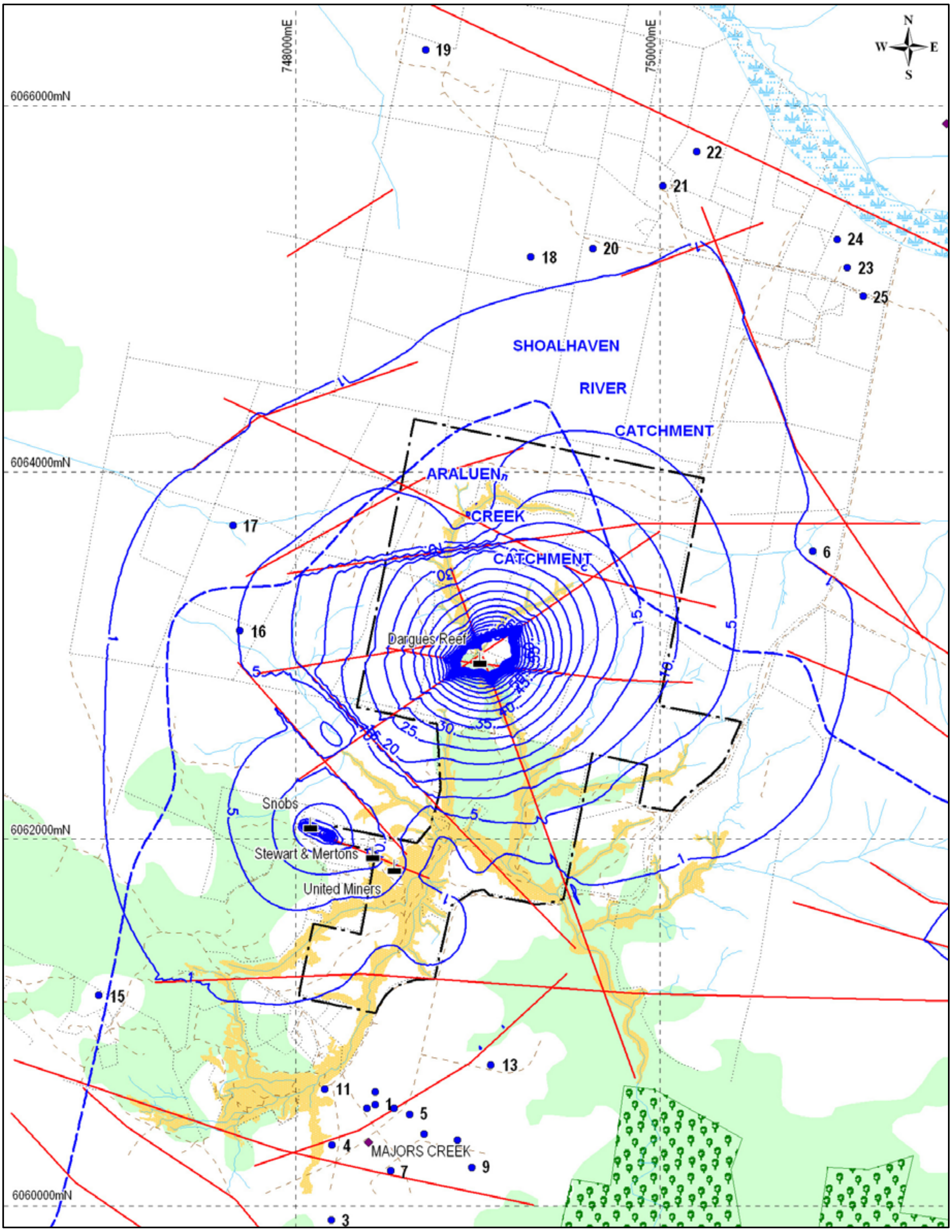
Year 3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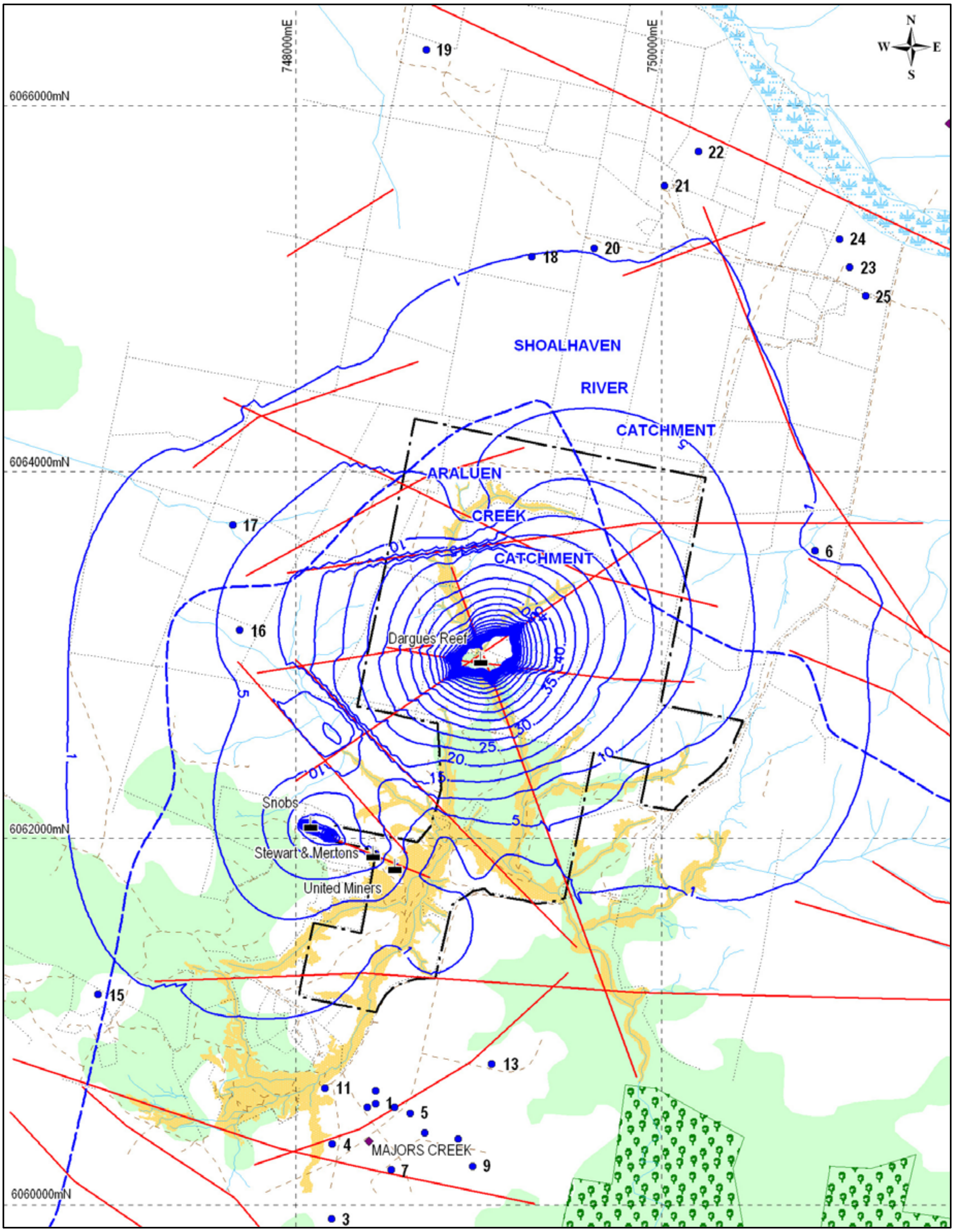
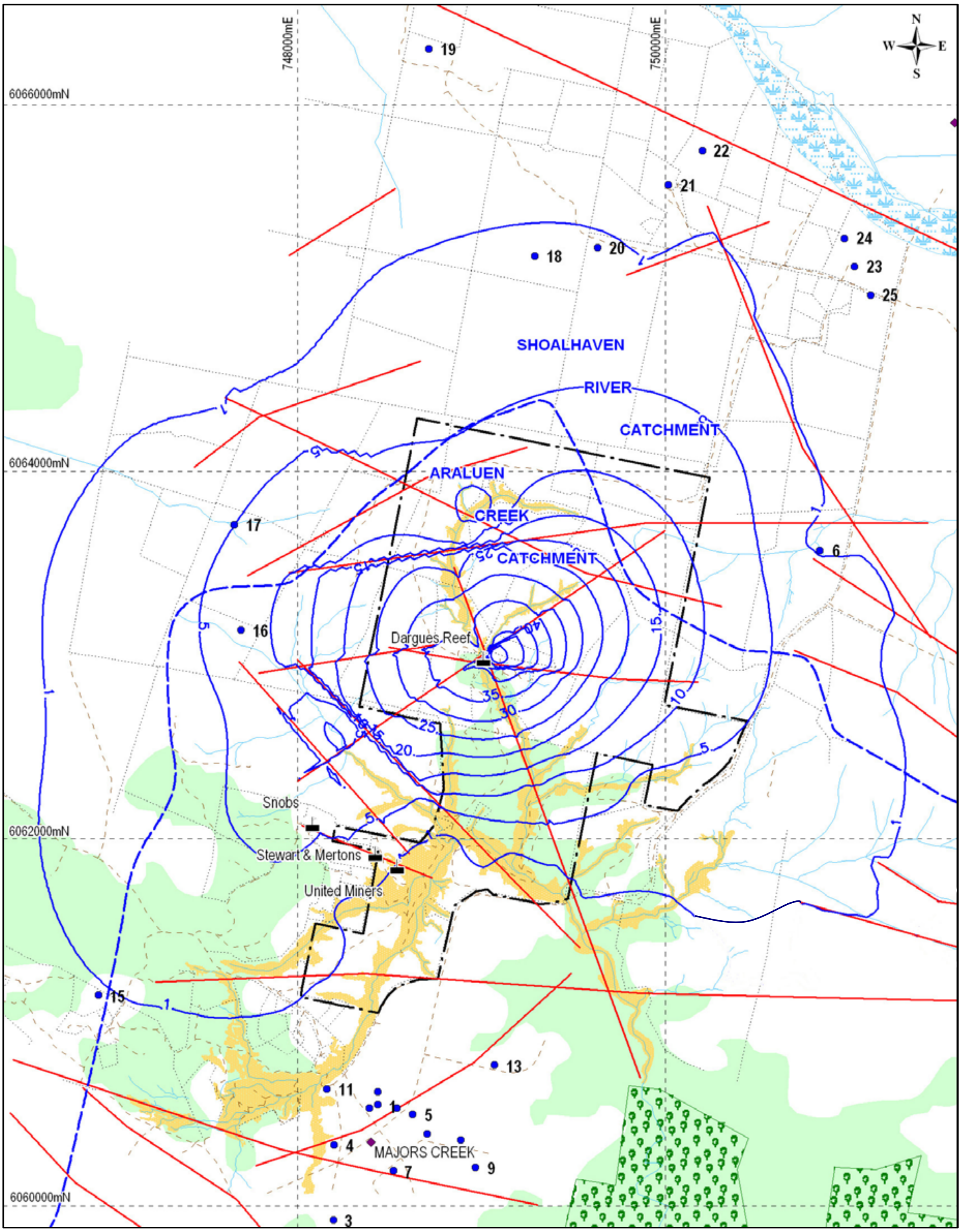
Year 4



Year 5 – End of mining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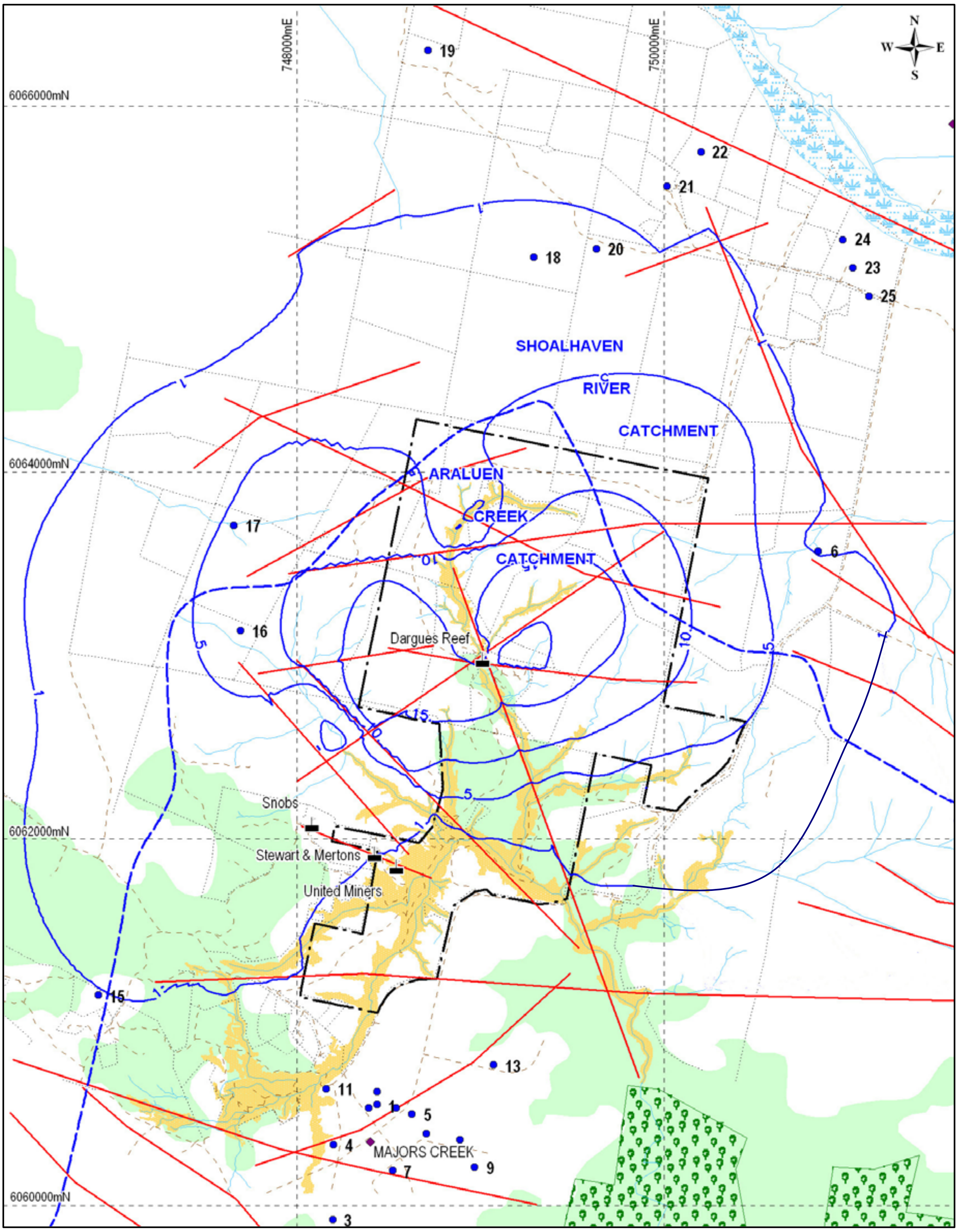
Year 6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Snobs
Stewart & Mertons
United Miners
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MAJORS CREEK
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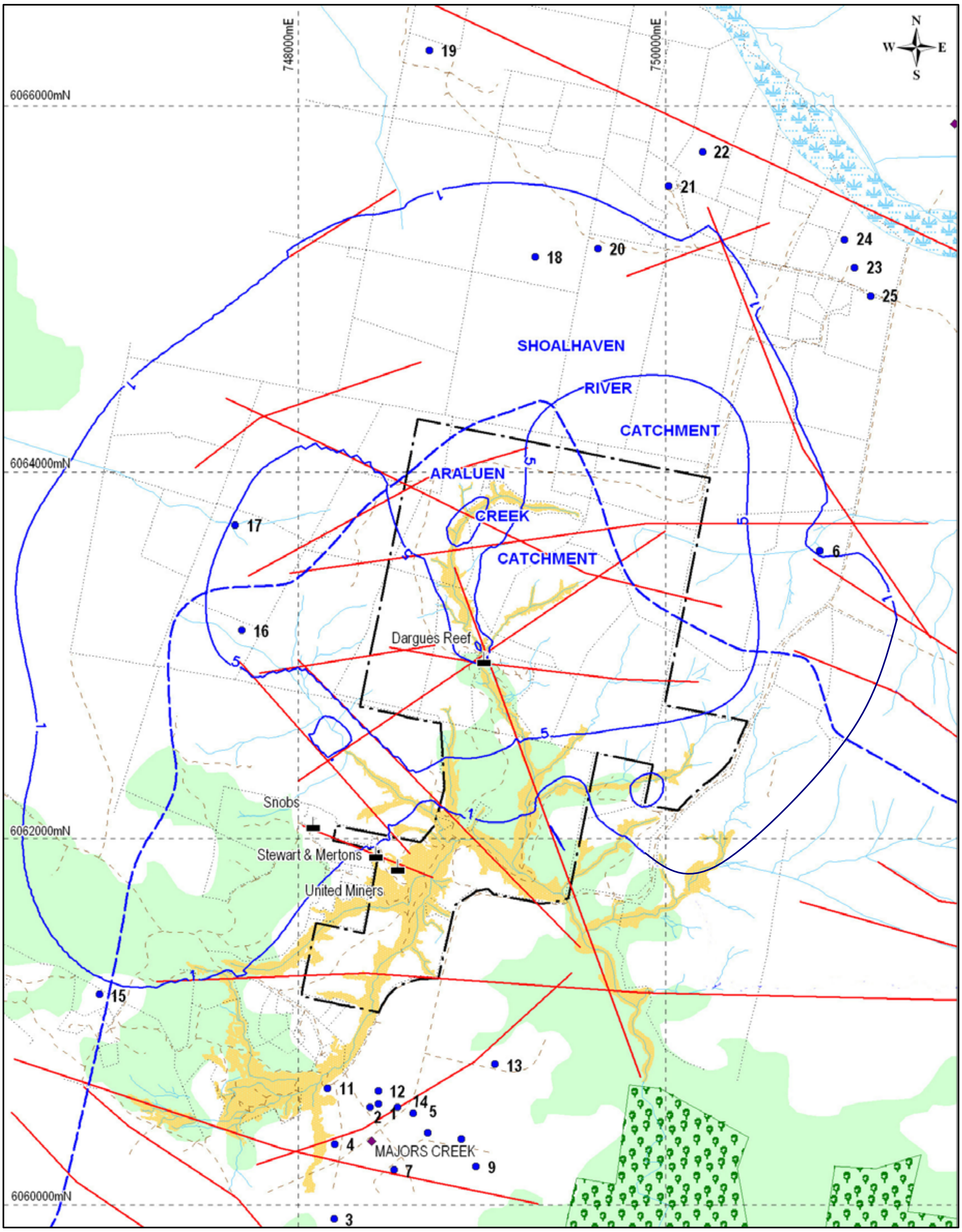
Year 7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MAJORS CREEK
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Year 8