APPENDIX 14f

China Stone Coal Project
EIS Extracts

July 2015

PROJECT CHINA STONE

Draft Environmental Impact Statement

EXECUTIVE SUMMARY

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MACMINES AUSTASIA

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INTRODUCTION

Hansen Bailey has prepared this draft Environmental Impact Statement (EIS) on behalf of MacMines Austasia Pty Ltd (MacMines) for Project China Stone (the project). The project involves the construction and operation of a large-scale coal mine on a greenfield site in Central Queensland (Figure 1). The project site is remote, being located approximately 270 km south of Townsville and 300 km west of Mackay, at the northern end of the Galilee Basin. The EIS has been prepared under the *State Development and Public Works Organisation Act 1971* (SDPWO Act) in support of an application for an Environmental Authority (EA), Mining Lease (ML) and approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

This Executive Summary provides a high level overview of the project, the environmental impact assessment process, and the key findings of the EIS.

The Proponent

The project proponent is MacMines Austasia Pty Ltd (MacMines). MacMines was registered and established in Queensland in 1999 and has since been focussed on geological exploration. MacMines holds a number of Exploration Permits for Coal (EPC) in Queensland, including EPC 987 which is split between a northern and southern block. The project site is located entirely within the southern block of EPC 987.

MacMines has been wholly owned by the Yao family since 2007 and is a related entity of Shanxi Meijin Energy Group Limited (Meijin). Meijin is also owned by the Yao family and was founded in 1981. Meijin is based in Qingxu County, Shanxi Province, China. Meijin is the largest manufacturer of commercial metallurgical coke in China and is the owner, operator and manager of a fully integrated mine to steel product chain.

Project Need

There are substantial undeveloped thermal coal resources within the project site. The project is proposed in order to efficiently extract these coal resources.

Thermal coal is used to generate electricity and currently accounts for about 40% of global electricity needs. Despite the recent softening in the price of thermal coal, the long term forecast is for demand to remain strong, particularly in Asia.

The project will provide substantial economic benefits to the region, Queensland and Australia. The project will create up to approximately 3,900 jobs during construction and up to approximately 3,400 jobs in the operations phase. The project will contribute up to $1,700 million annually to the economy of the Townsville and Mackay Regions during the operations phase. The project will also contribute significant revenue to the Queensland and Australian governments through coal royalties (approximately $5.9 billion over the life of the mine) and additional revenues associated with other government taxes.

FIGURE 1 LOCATION PLAN

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REGULATORY FRAMEWORK

Key Project Approvals and EIS Process

The key approvals required for the project are summarised in Table 1. These approvals are required prior to the commencement of construction of the project.

This EIS has been prepared for the project using the environmental impact assessment process under the SDPWO Act. The assessment process will culminate in an evaluation report being issued by the Coordinator-General (CG) who administers the SDPWO Act. The key approvals for the project under the MR Act, EP Act and EPBC Act, as shown in Table 1, will then be obtained.

Figure 2 shows the main steps in obtaining approval for the project (including the EIS preparation and approval process) and these steps are described below:

Preliminary Planning

Background investigations, including mine planning and the assessment of alternatives, were undertaken. During the project planning stage preliminary investigations into surface water and mine water management, groundwater, mine waste geochemistry and flora and fauna were undertaken. The results of these studies were taken into account in the project design and engineering assessment.

Declaration as a Coordinated Project

The CG declared the project a 'coordinated project' under the SDPWO Act on 31 October 2012. This declaration requires an EIS to be prepared in order to assess the potential impacts of the project.

Stakeholder Consultation

Consultation has been ongoing throughout the EIS process and is described further in Section 3. The interactions between community consultation and the EIS process are shown in Figure 2.

Terms of Reference

The draft Terms of Reference (TOR) for the EIS was placed on public exhibition, together with an Initial Advice Statement (IAS) in November 2012. The final TOR for the EIS was issued by the CG on 9 January 2013. The TOR was revised on 4 December 2014 to include the DotE's requirements for the assessment of Matters of National Environmental Significance (MNES) under the accredited assessment process.

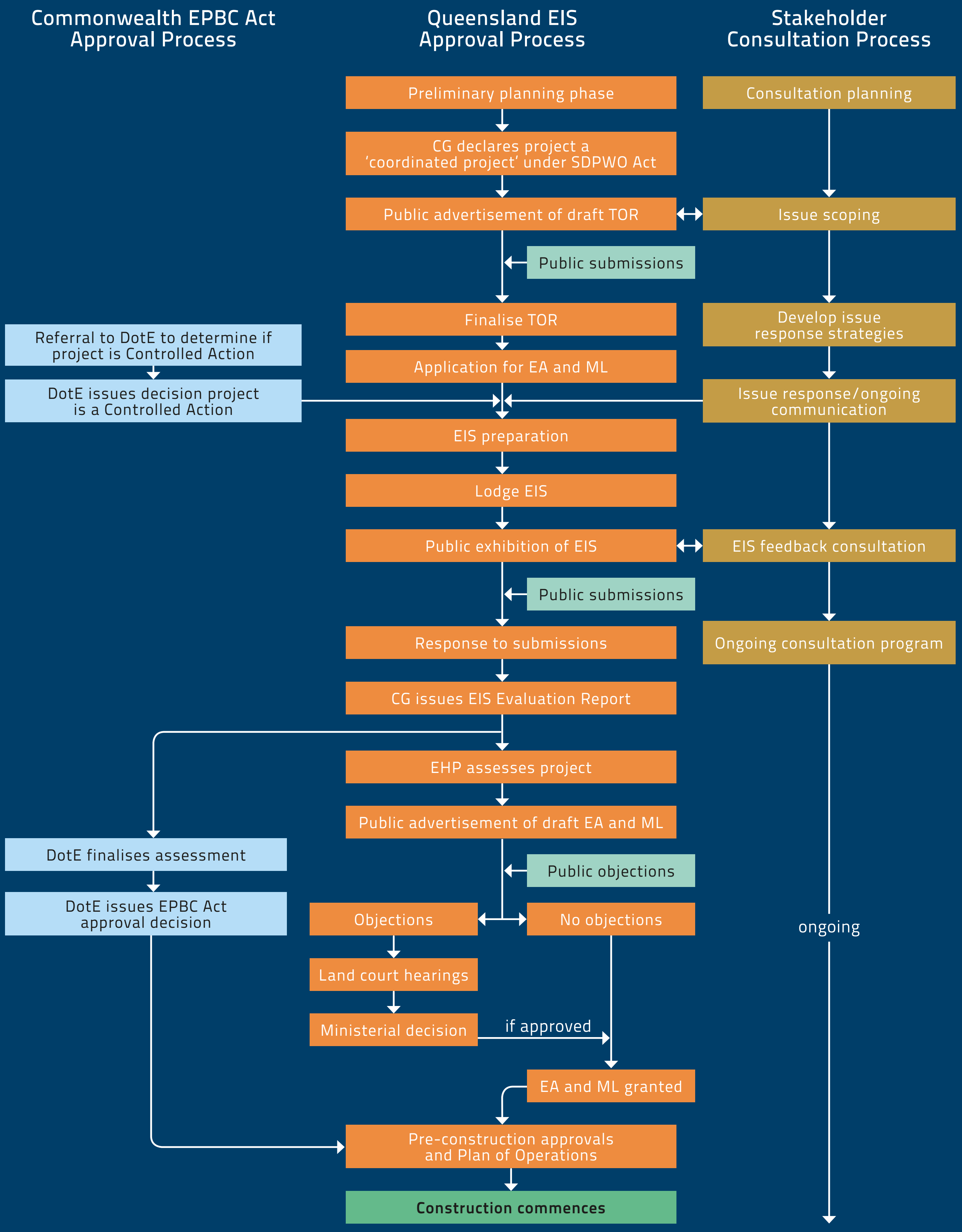
Application for EA and ML

The proponent lodged an EA and ML application with the DNRM on 30 January 2014. The EA and ML application was supported by a Preliminary Environmental Assessment Report. The EHP notified MacMines on 18 March 2014 that the EA and ML application requires additional information, which will be satisfied by this EIS.

TABLE 1 KEY PROJECT APPROVALS

APPROVAL	LEGISLATION	ADMINISTERING AUTHORITY
Mining Lease	Queensland *Mineral Resources Act 1989* (MR Act)	Queensland Department of Natural Resources and Mines (DNRM)
Environmental Authority	Queensland *Environmental Protection Act 1994* (EP Act)	Queensland Department of Environment and Heritage Protection (EHP)
EPBC Act Approval	Commonwealth EPBC Act	Commonwealth Department of the Environment (DotE)

FIGURE 2 PROJECT APPROVAL PROCESS



- **EPBC Act Controlled Action Decision**
  The project has been declared a Controlled Action under the EPBC Act, therefore requiring approval under the EPBC Act. The controlling provisions are EPBC Act listed threatened flora and fauna species and vegetation communities, listed migratory species and a water resource in relation to a large coal mining development. The DotE have determined that the project will be assessed using an accredited assessment under the SDPWO Act, meaning the DotE will make use of the EIS and the CG's EIS evaluation report prepared under the Queensland SDPWO Act for its assessment of the project's impacts on the controlling provisions.

- **EIS Preparation**
  The EIS was prepared following the completion of baseline studies, environmental input into project planning, and consideration of potential impacts and mitigation measures. The EIS studies were conducted by a team of multi-disciplinary technical specialists. The EIS was prepared in accordance with the requirements of the SDPWO Act and the EIS TOR and also considers issues and feedback from the stakeholder consultation program undertaken as part of the EIS process.

- **Lodgement and Public Exhibition of EIS**
  The preliminary draft EIS was submitted to the CG on 31 March 2015. Following approval by the CG to proceed, the draft EIS will be placed on public exhibition. During this period government agencies and the public are invited to make submissions to the CG. EIS comments and submissions must be made in writing and sent to the CG within the public exhibition period, as advertised in the EIS public notice.

- **Proponent Response**
  The CG will issue a copy of all accepted submissions to the proponent. The proponent will summarise and respond to submissions and provide the CG with any amendments to the EIS arising from the responses.

- **Assessment under the SDPWO Act**
  Once the CG has accepted the final EIS, the CG will prepare an EIS evaluation report which will include an evaluation of the environmental effects of the project and conditions and recommendations for the project. In conducting the evaluation of the EIS, the CG will consult with the relevant advisory agencies for the project. These will potentially include the Department of Transport and Main Roads, the Department of Agriculture and Fisheries, Queensland Health, Queensland Ambulance Service, Queensland Police Service, the Department of State Development, the Department of National Parks, Sport and Racing and the Department of Infrastructure, Local Government and Planning. The CG evaluation report is not an approval in itself; however it will include stated conditions that are required to be incorporated into the relevant key approvals that must be subsequently obtained from other agencies in order for the project to proceed. The CG will coordinate the EIS assessment by those other agencies. The CG evaluation report may also include conditions that are imposed by the CG and are enforceable under the SDPWO Act.

- **Assessment under the EP Act**
  The EHP will finalise their assessment of the EIS and develop a draft EA following receipt of the CG's EIS evaluation report. The draft EA will include the CG's stated conditions for the EA.

Ecologists conducting field survey

Draft EA and ML Application

The EHP will issue a draft EA for the project. The ML application documentation will be advertised and stakeholders may lodge objections to the draft EA and ML application.

EA and ML Decision

Any unresolved objections to the ML application and/or draft EA will be referred to the Land Court for a recommendation. The Land Court will make an objections decision and provide it as a recommendation to the Minister for the MR Act and the Minister for State Development. The Minister for the EP Act consults with the Minister for the MR Act and the Minister for State Development, and then the Minister for the EP Act makes a decision on the EA. The EA will be granted or the EA application refused.

Assessment under the EPBC Act

The CG's EIS evaluation report will also consider the impacts of the project on the declared controlling provisions under the EPBC Act and may include recommended conditions for the EPBC Act approval. The Federal Minister for the Environment will make a decision on approval and will impose conditions on the approval to protect MNES.

Pre-construction Approvals

Prior to the commencement of construction, the proponent will develop any necessary environmental management plans and will obtain any necessary pre-construction approvals including a Plan of Operations.

Secondary Approvals

The project requires approvals related to the management of the site and the environment, in addition to the key approvals listed in Table 1. These secondary approvals are listed in Table 2 and the EIS includes discussion of these approvals.

TABLE 2 SECONDARY APPROVALS

APPROVAL	LEGISLATION	APPROVAL BODY	TIMING
Plan of Operations	EP Act	EHP	Prior to commencement of the project
CG imposed conditions (contained in CG EIS Evaluation Report)	SDPWO Act	As specified in the conditions	As required by conditions.
Biodiversity offsets	Commonwealth EPBC Act Queensland *Environmental Offsets Act 2014* (EO Act) *Environmental Offsets Policy 2014* *Environmental Offsets Regulation 2014*	DotE EHP	Any applicable offsets will be conditioned as part of the EPBC Act approval and the EA.
Aerodrome certification	*Civil Aviation Act 1988* *Civil Aviation Regulations 1998*	Civil Aviation Safety Authority (CASA)	The private airstrip for the project will be designed and constructed in accordance with CASA regulations and guidelines. An aerodrome certification will be obtained, once it has been constructed.
Agreement with authorities to alter a stock route	*Land Protection (Pest and Stock Route Management) Act 2002* (LP Act)	DNRM	There is one travelling stock route, U398 which traverses the southern part of the project site within the mining disturbance footprint that may require re-alignment. The proponent will liaise with DNRM and the Isaac Regional Council regarding any alterations to the stock route, including obtaining any necessary agreements.
Licence for taking of or interference with groundwater	*Water Act 2000* *Water Resource (Great Artesian Basin) Plan 2006* (GAB WRP) *Water Regulation 2002*	DNRM	Prior to commencement of construction activities.
Approval to take native wildlife	*Nature Conservation Act 1992* (NC Act)	EHP	Prior to construction activities commencing, as required.
Species Management Program	*Nature Conservation (Wildlife Management) Regulation 2006* (NC WM Regulation)	EHP	Prior to tampering with an animal breeding place.
Rehabilitation Permit (spotter catcher endorsement)	NC WM Regulation	EHP	Prior to undertaking spotter catcher activities.
Damage Mitigation Permit	NC WM Regulation	EHP	If there is a need to remove fauna posing a threat to human health or wellbeing.
Cultural Heritage Management Plan (CHMP)	*Aboriginal Cultural Heritage Act 2003*	Department of Aboriginal and Torres Strait Islander Partnerships	A CHMP will be developed for the project with the relevant Aboriginal party, prior to the commencement of construction.

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CONSULTATION

A comprehensive stakeholder consultation program was undertaken as an integral part of the EIS process. It included consultation with the neighbouring landholders, local, state and federal government, community groups and other interested parties. The aim of the consultation program was to identify stakeholders' issues and to ensure that these issues were addressed as part of the EIS process. Figure 2 shows the interactions between the stakeholder consultation process and the EIS process.

The consultation program involved the five stages listed below.

- **Stakeholder Identification**
  The objective of this stage was to identify all relevant stakeholders in order to involve them early in the process.
- **Issue Scoping**
  The objective of this stage was to provide information on the project and EIS process to stakeholders to enable them to identify issues in relation to the project.
- **Social Impact Assessment Consultation**
  This stage occurred in parallel with the Issue Scoping Stage and was undertaken to validate the baseline profile of the study area, and assist in the identification and assessment of socio-economic impacts.
- **Issue Response**
  The objective of this stage was to address and proactively respond to all relevant stakeholder issues.
- **EIS Feedback Consultation**
  The objective of this stage is to provide feedback on the results of the EIS specialist studies to stakeholders. This stage will be undertaken during the EIS public exhibition period.

Consultation methods and tools have included community information sheets, one-on-one meetings, small group meetings, and telephone interviews.

Issues identified during consultation have been addressed in the project design and in the EIS.

hina Stone
unity Information Sheet
THREE
September 2014

Project China Stone is Macmines
(MacMines). MacMines was established
n 1999. MacMines' current interests
coal exploration areas in central Queensland.
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included landholders within and neighbouring the project site, state and local government agencies, service providers, community groups, Indigenous representatives and small business owners.

Based on feedback received during this consultation, a further round of consultation was conducted in June 2013. This second round of consultation included surveys of business capability in Charters Towers and Clermont. The results of the surveys have been collated and will be presented in the EIS. The findings of the surveys provided valuable information for consideration in the assessment of project socio-economic impacts and in the development of suitable management measures.

We would like to thank everyone who participated in the business capability surveys and in stakeholder consultation conducted for the project to date.

Approval Process Flowchart

Preliminary project planning
Advertisement of draft EIS Terms of Reference
Final EIS Terms of Reference issued
Preparation of EIS
Lodgement of EIS
Public exhibition of EIS
Response to submissions
EIS Assessment Report issued
Government determines whether project approvals are granted

We are here

ultation Program

Exhibition

rrently scheduled for submission to the
Government in late 2014. Following
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the EIS. Stakeholders will also have
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Stakeholder Information Sheets

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PROJECT DESCRIPTION

Project Overview

The project involves the construction and operation of a large-scale coal mine on a greenfield site in Central Queensland at the northern end of the Galilee Basin. The mine will produce up to 55 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal, which equates to approximately 38 Mtpa of thermal coal for the export market. The mine life will be in the order of 50 years.

Coal will be mined using both open cut and underground mining methods. Open cut mining operations will involve multiple draglines and truck and shovel pre-stripping. Underground mining will involve up to three operating longwalls in two underground mining areas. Coal will be washed and processed on site and product coal will be transported from the site by rail.

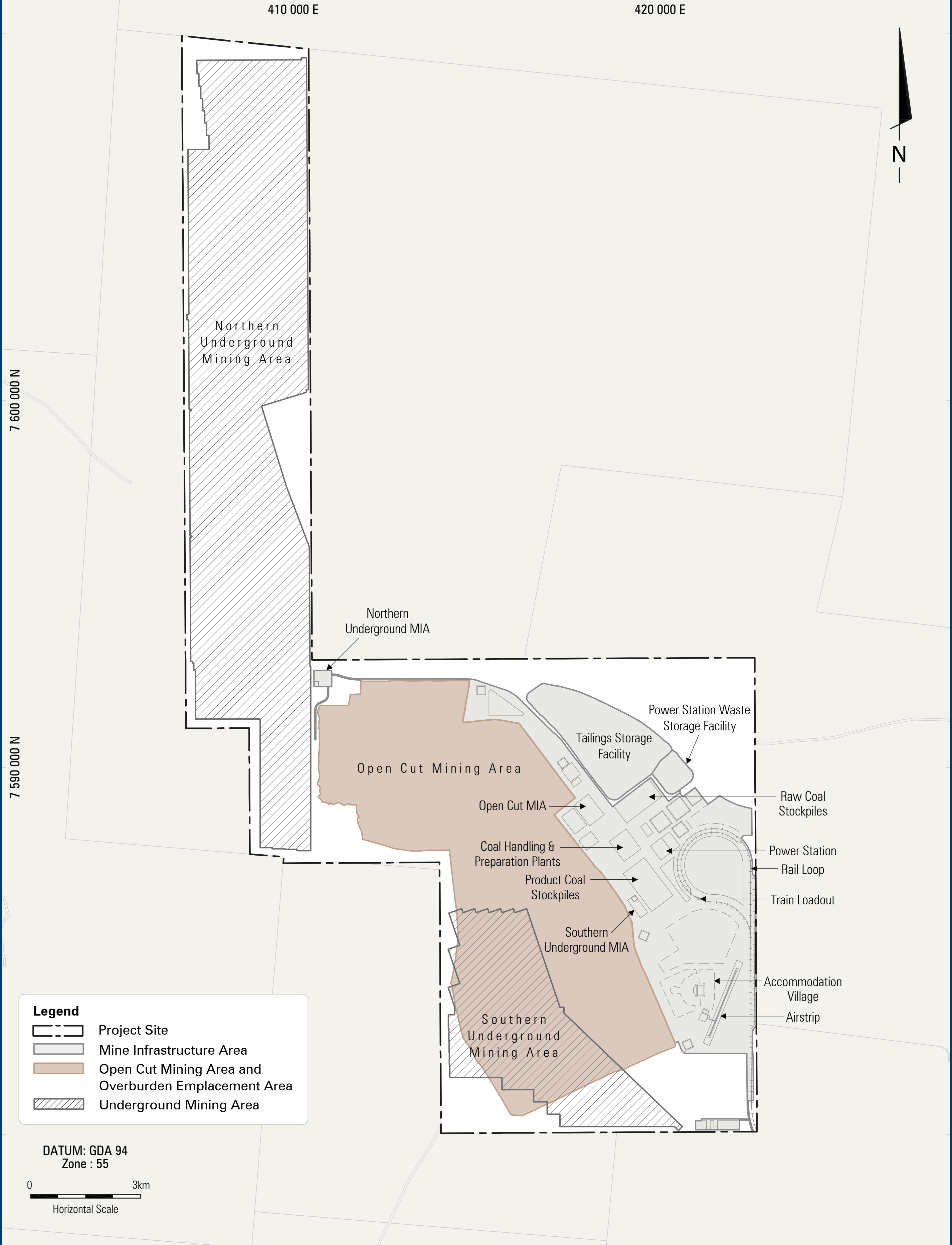
The majority of the mine infrastructure will be located to the east of the open cut mining area (Figure 3). It will include Coal Handling and Preparation Plants (CHPPs), stockpiles, conveyors, rail loop and train loading facilities, workshops and water storage dams.

Raw coal from the project will be washed at the CHPP. The washing of coal will generate coarse and fine rejects. Coarse rejects will be hauled by truck for storage within the overburden emplacement areas. Fine rejects, or tailings, will be transported via a slurry pipeline to a designated Tailings Storage Facility (TSF). The TSF will be a conventional tailings dam with sufficient storage capacity for life-of-mine tailings.

The project includes the construction and operation of an on-site power station and associated Power Station Waste Storage Facility (PSWSF). The power station will be used for mine power supply. It will comprise 350 Mega Watt (MW) air-cooled supercritical generating units utilising circulating fluidised bed technology. It will utilise coal rejects from the mine as feed coal. The PSWSF will involve the storage of dry power station waste including fly ash, bottom ash and clinker. These dry waste materials will be placed in the PSWSF using dump trucks in a similar manner to the development of an out-of-pit overburden emplacement. The PSWSF will have capacity for the storage of power station waste for the first 10 years of operations. After this time the power station waste will be buried within the overburden emplacements.

A workforce accommodation village will be located in the south-eastern part of the project site (Figure 3). The accommodation village will be constructed in stages in response to the progressive increase of the workforce during the project's development. The village will ultimately comprise approximately 3,050 rooms and will include facilities such as kitchens and mess halls, common rooms and recreation facilities, health and first aid facilities, and water and sewage treatment facilities.

FIGURE 3 PROJECT LAYOUT



Overburden removal by truck and excavator

A private airstrip will be constructed adjacent to the accommodation village for the transport of mine workers to and from the site (Figure 3). The airstrip will be designed to cater for a range of aircraft and will be designed, constructed and operated in accordance with CASA regulations and guidelines. Current planning estimates approximately 40 flights per week will be required during operations, from a range of coastal centres.

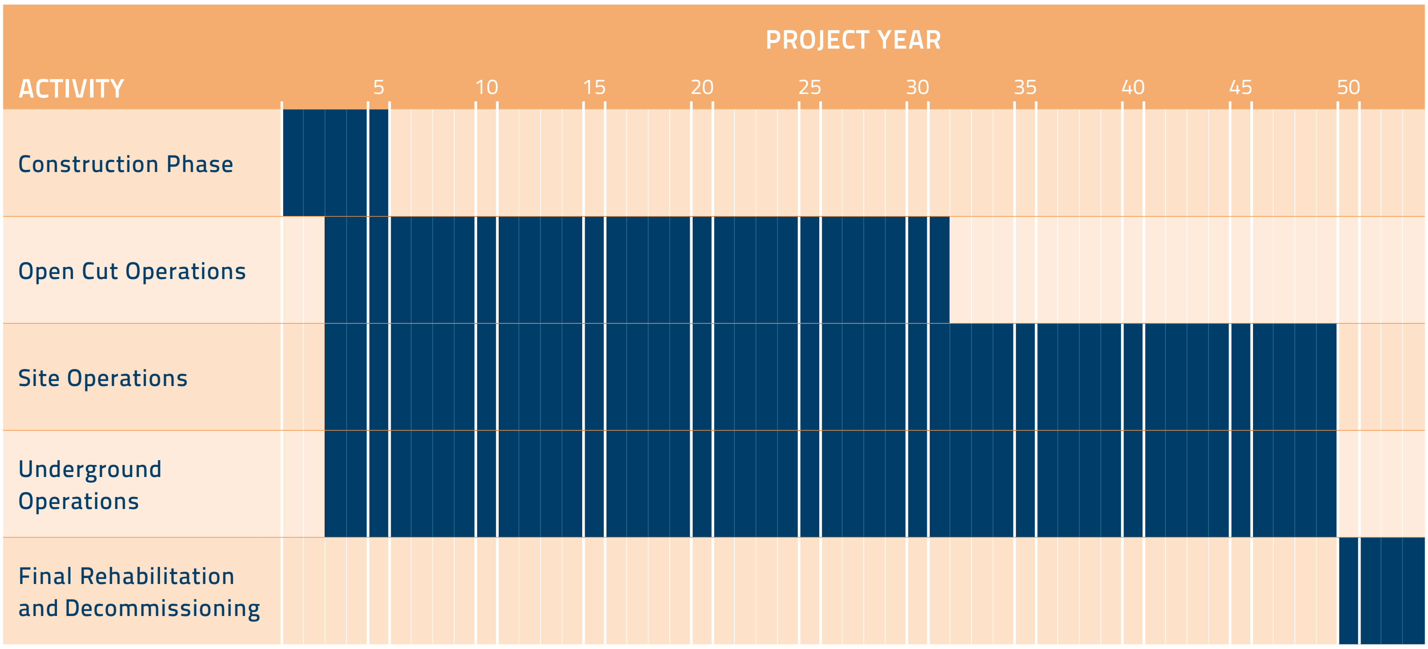
Minor surface facilities for the underground mines, such as ventilation shafts, underground communication cables, gas drainage and mine dewatering boreholes, will also be constructed progressively above the underground mining areas. There is considerable flexibility with respect to the location of these surface facilities and, as per current practice, these facilities will be sited to avoid significant surface features, as far as possible.

The scope of the EIS is limited to the mine site activities and does not include off-lease infrastructure that will be required for the project. Off-lease infrastructure will include port capacity, rail connection to port, mine site access road connection and raw water supply. These will be subject to separate environmental impact assessments and approvals. The current preferred option and status of each off-lease infrastructure component are discussed in the EIS.

Project Schedule

Chart 1 presents the relative timing of the key components of the project development schedule. It is important to note that this is an indicative schedule, subject to change based on detailed planning as well as economic and mining conditions. The timing of the commencement of construction is also subject to the receipt of environmental approvals, an ML and other necessary approvals. Construction of mine site infrastructure, including the accommodation village and airstrip is scheduled to commence in Project Year 1, which is currently anticipated to be 2016, subject to gaining the necessary approvals. Construction of mine site infrastructure is scheduled to be completed in Project Year 5. First coal production from the open cut and underground mines is scheduled for Project Year 3, once initial mine development works have been completed. Open cut mining is expected to be completed by Project Year 32 and underground mining would continue until Project Year 49. Mining will be followed by a final rehabilitation and decommissioning period.

CHART 1 PROJECT DEVELOPMENT SCHEDULE



Project Workforce

Chart 2 illustrates the anticipated project workforce by project phase, based on current project planning. The size of the project workforce for the construction and operations phase will fluctuate over time, reflecting changes in the construction and mining activities. The anticipated peak workforce during the construction phase is 3,892 persons during the fourth year of the project.

There are two distinct operations phases for the project. Operations phase 1 includes the operation of the open cut mine, as well as operation of the three underground longwall mines. Operations phase 1 represents the peak operations phase for the project and runs from Project Year 6 to Project Year 31. Operations phase 1 will have an average annual workforce of 3,119 persons across the phase and a peak workforce of 3,391 persons in Project Year 8. Operations phase 2 runs from Project Year 32 to Project Year 49 and commences following the completion of open cut mining. Mining operations in phase 2 are limited to underground longwall mining in the Northern Underground. This phase has an average annual workforce of 1,016 persons. The peak workforce in this phase is 1,377 persons in Project Years 32-34.

At the completion of mining in Project Year 49, a four-year Final Rehabilitation and Decommissioning Phase will run from Project Year 50 to Project Year 53. A small decommissioning workforce is expected to be required for this phase, with a peak of 275 workers in Project Year 50.

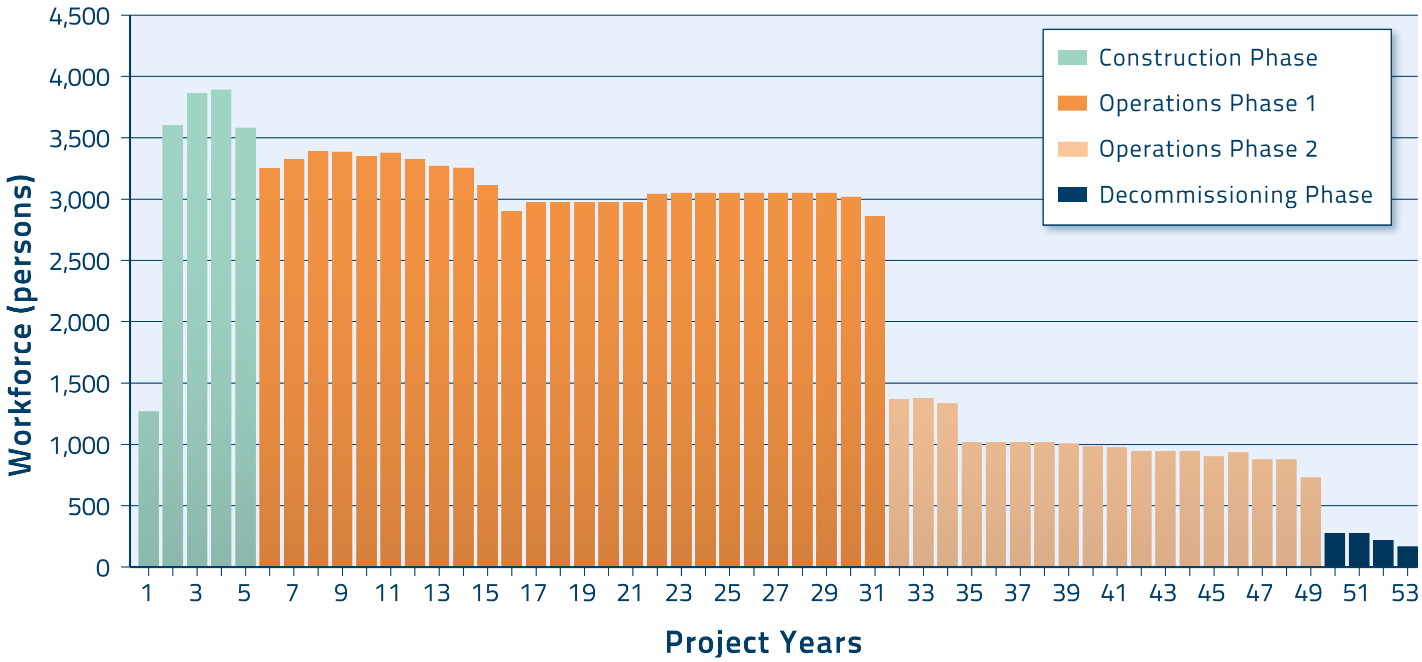
Project Alternatives and Justification

Project Alternatives

The key aspects of the project where alternatives were considered during project planning include:

- **Alternative mining methods**
  The project involves mining the shallower coal seams by open cut mining, and the deeper coal seams by underground mining. The coal seams in the open cut mining area are thick and could not be extracted by underground mining methods with an acceptable level of resource recovery or economic viability. Open cut mining is not economically viable for the deeper underground seams. The proponent intends using conventional longwall mining methods to extract the deeper target seams. Alternative underground mining methods, including Longwall Top Coal Caving and bord and pillar mining, were considered. Longwall Top Coal Caving was considered in the A seam in the Northern Underground, however it is not proposed due to the uncertainty and associated risk in relation to its technical feasibility. Although bord and pillar mining would result in reduced surface subsidence effects in the underground mining areas, it was not considered further due to the lower resource recovery, lower productivity and higher operating cost which is not feasible for a high production capacity mining operation.

CHART 2 PROJECT WORKFORCE



- **Alternative project layout**
  The project site, although large, is highly constrained by the large scale open cut mining operations and the limited suitable area available for mine infrastructure. The location of the open cut mine is determined by the shallower target coal seams. The location of the underground mining areas is determined by the location of the deeper target coal seams, and the mine layouts are designed to maximise resource utilisation. The eastern portion of the project site is the only suitable and sufficient area available for the construction of the mine infrastructure. In order to minimise the impact of the project on downstream drainage, the design of the mine infrastructure area includes drainage corridors at the northern and southern ends with capacity to convey drainage through the site. The northern corridor has been designed to avoid disturbance of a drainage line traversing the north-eastern corner of the site.

- **Alternative tailings storage strategies**
  Alternative tailings storage options that were considered included storage within the open cut pits and disposal of dewatered tailings within the overburden emplacement areas. The option for in-pit storage was not progressed for the purposes of the EIS as it is not feasible in the initial years of operations due to a lack of available in-pit storage area. The potential feasibility of this option in later years would be subject to detailed production scheduling, open cut mine planning and open cut mine scheduling, as well as detailed geotechnical investigations. This option may be considered again in the future, subject to the completion of favourable feasibility studies and gaining the necessary approvals. Disposal of dewatered tailings in the overburden emplacement was also considered; however due to the volume of tailings being generated by the project, mechanical dewatering of the tailings is not considered economically viable. A conventional tailings dam is proposed as it is a proven and economically viable option considering the volume of tailings generated by the project.

- **Alternative power supply**
  Alternative power supply options, including the construction of a high voltage transmission line to connect to the existing power grid, were considered as part of project planning. This option was not preferred due to the considerably higher operating and power purchase costs over the 50 year mine life, the long lead time for a connection, and potential transmission loss due to the long distances involved. The low cost power supply provided by an on-site power station is fundamental to the economic feasibility of the project. It also results in higher resource utilisation and greater security for power supply.

- **Alternative workforce strategy**
  Alternative workforce strategies that were considered included the option for workers to live locally, construction of an off-lease township, and a shared accommodation village or township with Adani Mining Pty Ltd (Adani). Due to the remote location of the project site and the lack of surrounding amenities or infrastructure, there are limited options for workers to live locally or to create an off-site township. At present, Adani's proposed accommodation village is approximately 30 km from the project site, so the option of an on-site accommodation village is considered the most suitable for the project workforce. However, the proponent will continue discussions with Adani regarding the possibility of a shared facility.

- **Alternative open cut ROM coal transport options**
  In-pit coal crushing and transport of raw coal from the open cut pits to the CHPP raw coal stockpiles by conveyor is an alternative to transporting coal from the pits in haul trucks. The EIS studies have been based on haulage of open cut coal by truck as this would be the worst case with regard to potential environmental impacts. For example, the noise and dust emissions from coal haul trucks would be higher than a coal conveyor. A final decision on the preferred transport option for open cut coal will be made during detailed mine planning.

Project Justification

The proponent's justification for the project is:

- It involves a responsible mine plan that incorporates appropriate constraints and control measures to limit any adverse environmental and social impacts to an acceptable level;

- It maximises the responsible utilisation of the coal resource; and

- It will result in significant economic benefits for the local area and Queensland, including substantial job creation, the addition of potentially $1.5 billion annually to the gross state product of Queensland, and payment of an annual average of $188 million to the Queensland Government through coal royalties.

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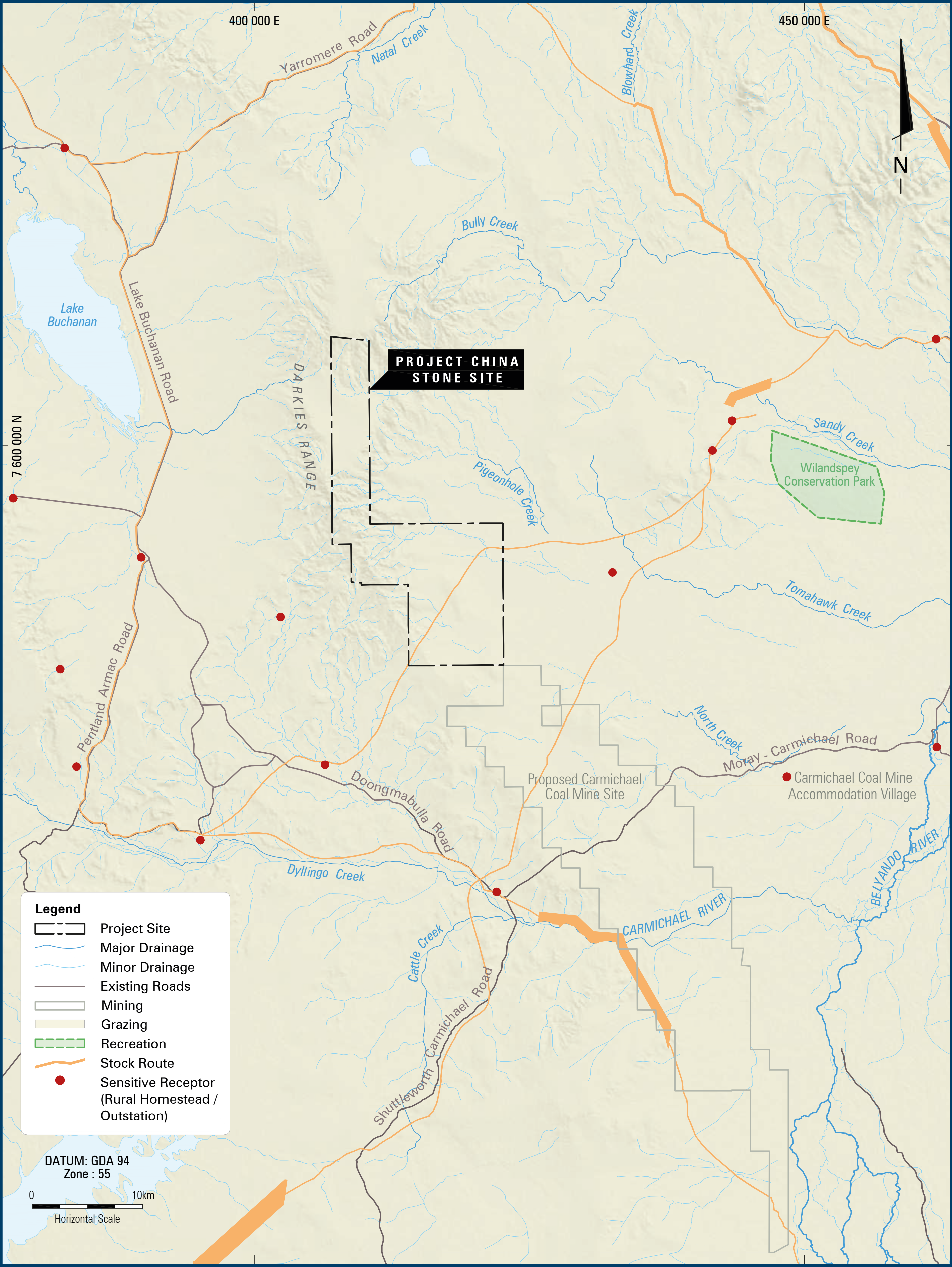
LAND USE

Surrounding Land Use

Land use surrounding the project site is shown on Figure 4, and includes:

- Grazing, which is the primary land use within the project site and surrounding area. A stock route traverses the southern part of the project site.
- Coal resource exploration and future mining at the proposed Carmichael Coal Mine, a proposed 60 Mtpa (product) open cut and underground coal mine that adjoins the project site to the south-east. The Carmichael Coal Project is currently in the approval phase.
- Remote, isolated rural residences with the closest homestead being located approximately 7.2 km to the west of the project site. The nearest settlement is Belyando Crossing (population of approximately five people) which is located approximately 140 km by unsealed roads to the east of the project site.
- Recreation including Lake Buchanan which is located approximately 20 km to the north-west of the project site and is used by the local community for recreational activities such as water-skiing, camping and picnics. Wilandspey Conservation Park is located approximately 25 km to the east of the project site and is used for outdoor recreational activities, tourism and for the preservation of natural ecosystems.

FIGURE 4 LAND USE



Sensitive Receptors

Sensitive receptors that have been identified in the vicinity of the project site are shown on Figure 4 and include a number of isolated rural residences and the proposed Carmichael Coal Mine accommodation village.

Project Site

The project site comprises approximately 20,000 ha of well vegetated land, with low-lying scrub in the south and east and a densely vegetated ridgeline, known as Darkies Range, running north to south through the western portion of the site.

The south-eastern portion of the site is characterised by flat to undulating plains with sandy loam soils that support large expanses of savannah woodlands. These sand plains graduate to elevated sandstone ranges to the north and west of the project site that support low Eucalyptus woodlands and shrublands. The project site itself is relatively dry and is characterised by ephemeral drainage lines, two seasonal wetlands and two artificial farm dams.

Sensitive environmental areas within the project site include a number of areas or features identified as Matters of State Environmental Significance (MSES) and/or MNES. These include one of concern Regional Ecosystem (RE), one wetland mapped as a wetland of High Ecological Significance, remnant riparian vegetation, and four threatened fauna species and one additional fauna species listed as special least concern. One near threatened fauna species was also identified. Potential impacts on these ecological features are addressed within the EIS.

The project site is located on three parcels of Crown land, leased by three separate lessees. The proponent has commenced discussions with all affected landholders in relation to obtaining access to the land for the project.

The project site includes land that may be subject to Native Title and is within the Wangan and Jagalingou People's registered Native Title claim application. The proponent will negotiate with the Wangan and Jagalingou People, as the registered Native Title claimants, in accordance with the requirements of the Commonwealth *Native Title Act 1993*.

Existing land use within the project site is limited to cattle grazing and coal mining exploration.

Land Use Compatibility

The development of the project is compatible with the current surrounding land uses which include grazing, mining exploration and future mining development. Although the development of the project will result in a change to the rural character of the region, the project will not have a significant impact on the surrounding rural residences or recreation areas in terms of air quality, noise, aesthetic impacts and community values.

Beef cattle on the project site

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SUBSIDENCE

The project involves establishing up to three longwall operations in the Northern and Southern Underground Mining Areas (Figure 5). The Southern Underground will involve single seam longwall mining. The majority of the Southern Underground is located beneath the open cut mine. The Northern Underground will involve both single and dual seam longwall mining.

Longwall mining typically results in subsidence which leads to the progressive development of shallow, trough-like depressions on the surface above each extracted longwall panel. The trough-like depressions have gentle grades and develop relative to the natural surface topography. Detailed subsidence predictions have been prepared to enable the assessment of subsidence effects and development of suitable rehabilitation strategies.

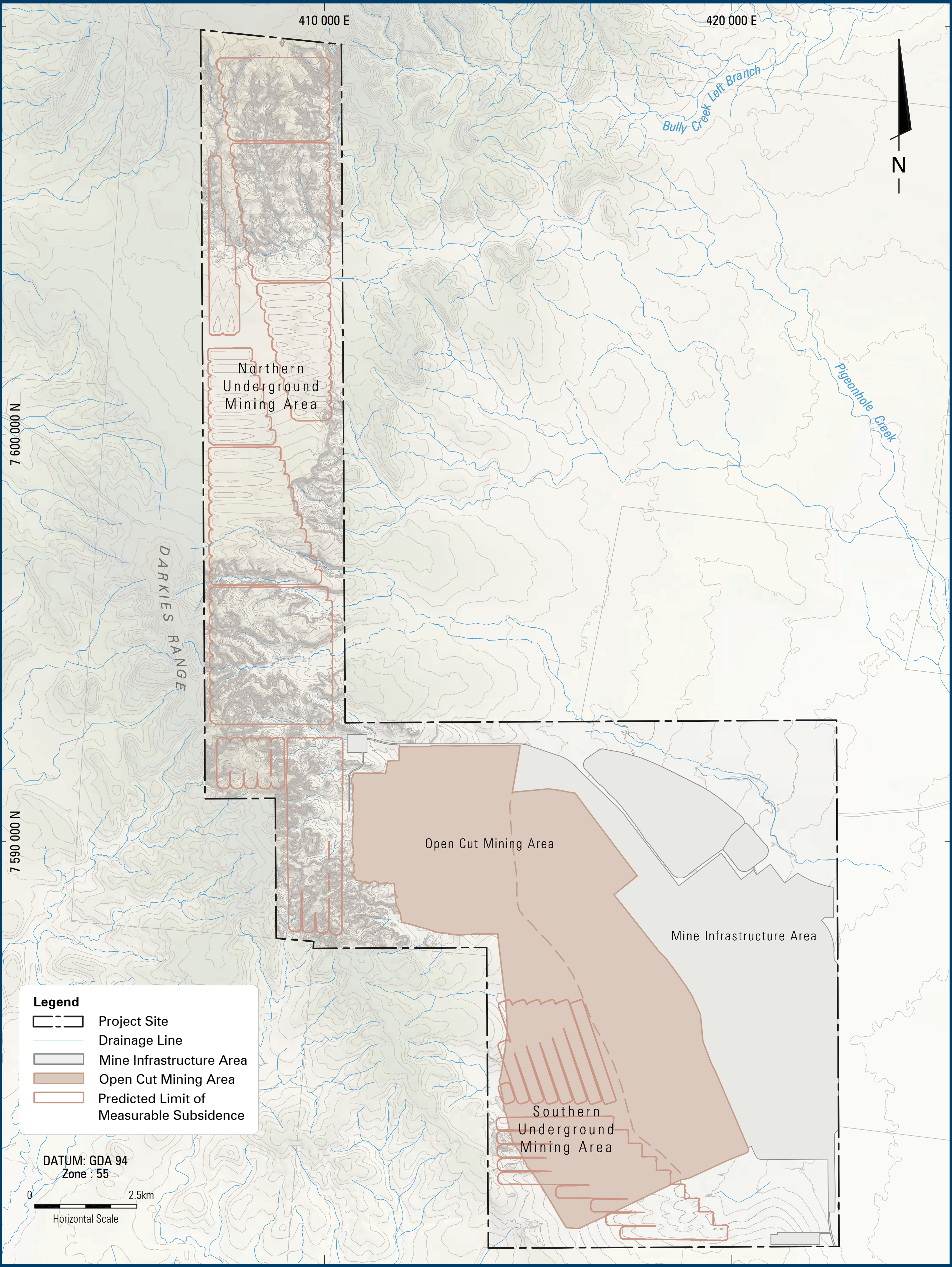
The aerial extent of predicted surface subsidence is shown in Figure 5. This area is defined by the predicted Limit of Measurable Subsidence and covers an area of approximately 4,950 ha. Subsidence may give rise to localised surface cracking within the predicted subsidence area due to tensile strain on the ground surface. Residual tensile strain and potential tension cracks will occur around the perimeter of each underlying longwall panel. The exact location of cracks can only be confirmed through monitoring, although the majority of the subsided surface area will be unaffected by cracking. Residual tension cracks occur within a few weeks of an area being mined.

Tension cracks are anticipated up to a maximum width of 0.2 m, and larger cracks may occur in isolated locations. A tension crack rehabilitation program has been developed for the project, which involves monitoring areas potentially subject to tension cracking and repairing any cracks that develop. This targeted method of surface subsidence crack rehabilitation has been proposed in order to minimise disturbance of vegetation. This method is consistent with the method used at a number of operating longwall mines in Central Queensland.

Subsidence troughs can result in localised alteration of surface drainage paths and can create ponding areas. Minor remedial drainage earthworks will be installed as required to re-establish free drainage in any ponding areas. There will consequently be no significant residual ponding impacts, and no significant changes in the existing surface drainage regime.

The effect of subsidence on the natural features and environmental values within the project site was assessed in the relevant technical studies prepared for the EIS. The assessment of subsidence impacts and the development of mitigation and management measures have drawn on operational experience at other comparable longwall mining operations. Subsidence impacts will be managed in accordance with a Subsidence Management Plan. The conclusion of the impact assessment is that the effects of subsidence on natural features will be manageable and will not give rise to any long term adverse impacts.

FIGURE 5 MINE SUBSIDENCE AREAS



7

TAILINGS AND POWER STATION WASTE STORAGE FACILITIES

The project will generate the following mine wastes that will be stored in dedicated storage facilities on the project site:

- Tailings generated by processing coal at the CHPPs. Life-of-mine tailings will be stored in a conventional wet TSF. The tailings will be pumped from the CHPP to the TSF as a slurry via a surface pipeline.
- Dry power station waste material (fly ash, bottom ash and clinker) generated by the power station. Waste from the power station will be transported by haul truck for storage in the PSWSF. The PSWSF will be a dry emplacement area constructed in a similar manner to an out-of-pit overburden emplacement. The PSWSF will have sufficient capacity to store power station waste for the first 10 years of operations. After this time, power station waste will be stored within the open cut mine overburden emplacement areas.

The proposed management and storage strategies for mine wastes have been informed by the geochemistry of these materials with respect to their potential risk to cause harm to the environment. The geochemistry assessment conducted for the EIS has found that the tailings and power station waste material are likely to be benign and non-acid forming. Accordingly no special management measures or rehabilitation techniques are required in relation to the geochemistry of these materials.

The EIS includes conceptual designs for the TSF and PSWSF, which were informed by geotechnical assessment of the storage facility foundation areas and landform stability analysis. The layout of the TSF and PSWSF is shown in Figure 6.

The TSF has been designed with a total storage capacity of approximately 96 Mm^3. This is sufficient storage for the life of mine tailings production. The final TSF footprint will be approximately 603 ha and the maximum TSF embankment height will be approximately 34 m. The external embankment slopes of the TSF will be 6H:1V.

The TSF will have an isolated internal catchment and tailings will be discharged from the embankments in order to maintain a central decant water pond. Tailings supernatant and runoff will collect in the decant pond. A low water level will be maintained in the decant pond by pumping collected water to the Return Water Dam for storage and re-use in the CHPP. Any seepage from the TSF will be collected in a seepage collection drain and returned to the TSF decant pond.

The PSWSF has been designed with a total storage capacity of approximately 16 Mm^3. The final PSWSF footprint will be approximately 80 ha and the maximum PSWSF height will be approximately 30 m. The external slopes of the PSWSF will be 6H:1V and the top surface of the PSWSF will have a 2% grade to promote runoff.

The PSWSF catchment will be isolated by perimeter diversion drains. The active PSWSF areas will be constructed to be internally draining to collection sumps. Collected runoff from the PSWSF will be transferred to the TSF decant pond. Any seepage from the PSWSF will be collected in a seepage collection drain and transferred to the TSF decant pond.

FIGURE 6 TSF AND PSWSF LAYOUT – YEAR 30

8

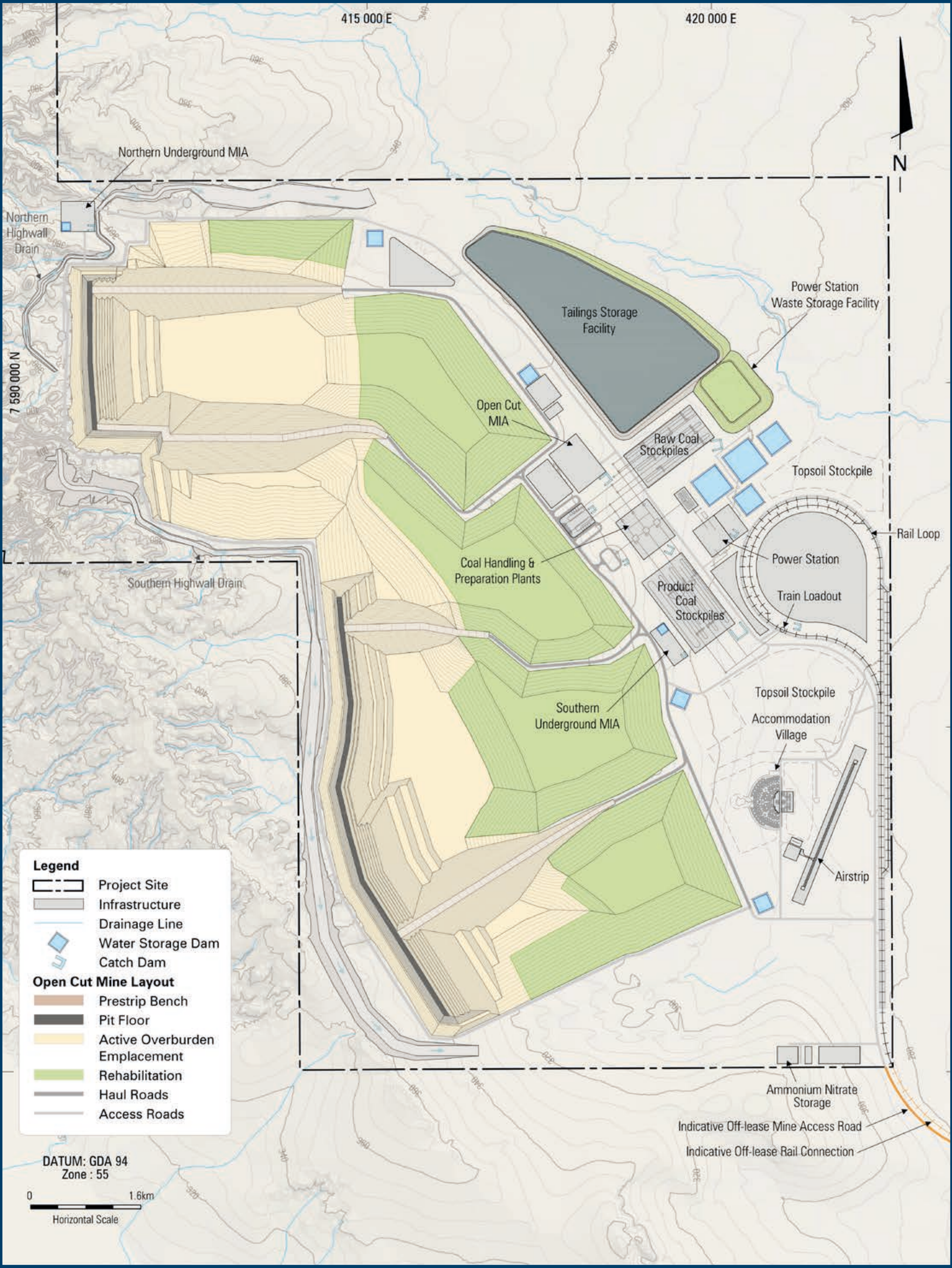
REHABILITATION

Rehabilitation and Mine Closure

Rehabilitation will be undertaken in accordance with a Rehabilitation Management Plan. Rehabilitation activities that will be undertaken as part of the project include progressive rehabilitation of overburden emplacement areas, areas disturbed by subsidence, and the TSF and PSWSF.

Overburden emplacement areas will store overburden excavated from the open cut mining areas as well as coarse coal rejects, generated from the processing of coal at the CHPPs, and power station waste after the PSWSF has been filled to capacity. The geochemical characterisation of these materials indicates they are all likely to be benign and non-acid forming.

FIGURE 7 OPEN CUT MINE LAYOUT – YEAR 30



The overburden materials are also likely to have low sodicity levels and therefore have a relatively low risk of being susceptible to significant dispersion and erosion. Accordingly no special management measures or rehabilitation techniques are required for the overburden emplacement areas and the project will implement a conventional rehabilitation strategy. This will include maximum external slopes of 6H:1V and a 2% grade on the top plateau areas to promote runoff (Figure 7).

As discussed previously, underground longwall mining will result in surface subsidence, surface tension cracks and surface buckling effects in localised areas. Subsidence may also result in ponding of water in shallow surface depressions. There are no significant waterways within the area that will be affected by mine subsidence. However, any minor drainage lines that are subsided will be monitored and remedial measures will be implemented to address any areas of erosion or instability. Rehabilitation of surface subsidence effects will be conducted in accordance with a Subsidence Management Plan.

Rehabilitation of the completed TSF and PSWSF will involve provision of capping and topsoil layers, and seeding. A self-sustaining native ecosystem will be established on the TSF and PSWSF landforms.

Rehabilitation of areas disturbed by the construction of mine infrastructure will be undertaken as part of mine decommissioning and closure in accordance with a Mine Closure Plan. Mine infrastructure will be dismantled and removed from site and infrastructure areas will be rehabilitated during mine closure.

The open cut mine final voids and ramps will be left in a geotechnically stable form. The catchment area of the final voids will be limited by highwall drains and the direction of drainage from the overburden emplacement area away from the voids, where possible. Modelling of the final void water balance indicates that a lake will form in the final void. The modelling indicates that the lake will reach a quasi-equilibrium level approximately 50 m below the spill point of the final void. Overflow from the final void is therefore very unlikely. The predicted lake level is also below the level of the pre mining water table. This means that the final void will continue to act as a groundwater sink in the post mining phase and void lake water will not migrate way from the void and will not potentially affect groundwater quality. Groundwater modelling also indicates that groundwater inflows to the final void will be relatively minor in the post mining phase, based on conservative groundwater modelling assumptions.

The decommissioned site will be free draining with the exception of the final voids. Flood modelling conducted for the EIS indicates that the decommissioned site has a suitable drainage arrangement and the final voids will have immunity from the Probable Maximum Flood.

Soils and Land Suitability

A comprehensive soils and land suitability assessment was undertaken, covering the full extent of the site. The majority of the project site is considered agricultural land class C3 and is suitable for light grazing of native pastures in accessible areas. The remainder of the project site is agricultural land class D which is land not suitable for agricultural uses. Post mining land suitability will be similar to pre mining land suitability, with the exception of the areas disturbed by open cut mining, including the overburden emplacement areas and final void, and the TSF and PSWSF. No grazing is proposed on these areas in order to protect the integrity of the rehabilitation. These areas will be revegetated to achieve a self-sustaining native ecosystem post mining.

The soils assessment has identified there is a significant surplus of topsoil resources on the project site for the proposed rehabilitation activities including suitable capping resources for rehabilitation of the TSF and PSWSF. The depth of available topsoil resources varies from 0.1 m to 1.3 m. A Topsoil Management Plan will be developed to manage topsoil resources for the project.

Scraper used for topsoil stripping

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TERRESTRIAL ECOLOGY

The EIS includes a detailed ecological assessment that involved multi-season terrestrial flora and fauna surveys. The entire project site is remnant vegetation comprising Eucalyptus and Acacia open woodland.

One vegetation community listed as of concern under the *Vegetation Management Act 1999* is present within the project site, namely RE 10.10.3 *Eucalyptus drepanophylla* open-woodland on sandstone ranges.

RE 10.10.3 occurs as a minor component of a number of mixed vegetation communities. A total of approximately 271 ha of RE 10.10.3 occurs within the project site (Figure 8). There are no groundwater dependent ecosystems in the project site, given the lack of shallow groundwater.

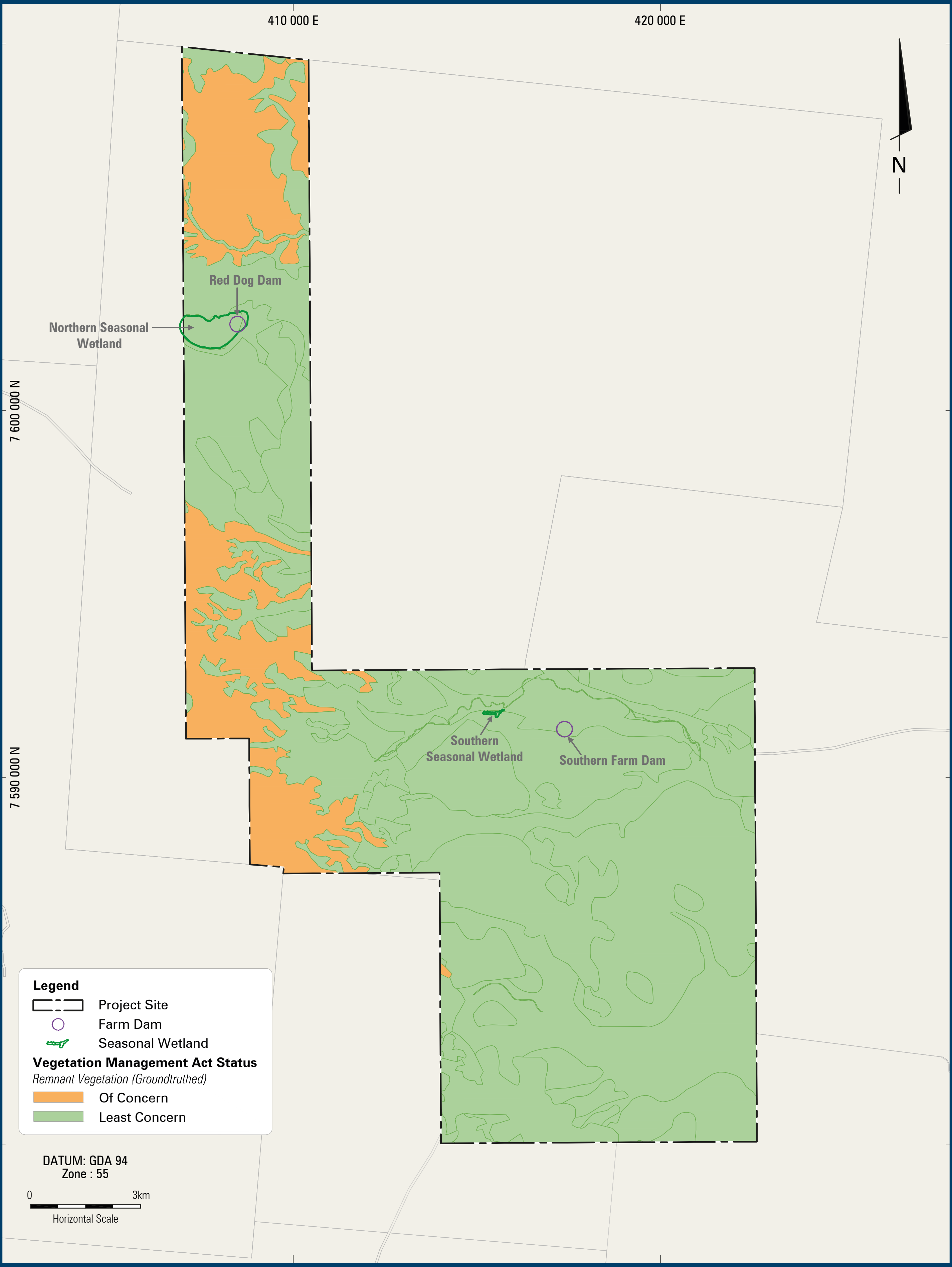
No threatened flora species listed under the NC Act were recorded or are considered likely to occur within the project site.

The following threatened and/or special least concern fauna species listed under the NC Act were recorded on the project site:

- Squatter Pigeon (southern subspecies) (*Geophaps scripta scripta*) (vulnerable);
- Black-throated Finch (white-rumped subspecies) (*Poephila cincta cincta*) (endangered);
- Koala (*Phascolarctos cinereus*) (special least concern); and
- Short-beaked Echidna (*Tachyglossus aculeatus*) (special least concern).

In addition, the Australian Painted Snipe (*Rostratula australis*), listed as vulnerable under the NC Act, was assessed as having a moderate potential to occur on the project site.

FIGURE 8 VEGETATION COMMUNITIES



The EIS includes an assessment of potential impacts on flora and fauna. The assessment considered direct impacts due to vegetation clearing for open cut mining and the construction of mine infrastructure. Potential impacts including the loss of habitat features, habitat fragmentation and indirect impacts such as the effects of noise and vibration, vehicle strikes, lighting, dust, erosion and the introduction of invasive species were also assessed. Impacts arising from subsidence, specifically the disturbance of vegetation as a result of the subsidence crack rehabilitation program and the installation of minor remedial drainage earthworks were also assessed.

The project will give rise to potentially significant residual impacts on the Squatter Pigeon (southern subspecies), Black-throated Finch (white-rumped subspecies) and Koala. The EIS contains a Biodiversity Offset Strategy which describes the offsets that will be provided for impacts on these species. The EIS does not predict any significant impacts on the Australian Painted Snipe or the Short-beaked Echidna.

The project will also give rise to potentially significant residual impacts on vegetation classified as MSES. Open cut mining and the construction of mine infrastructure will clear approximately 24 ha of RE 10.10.3 and approximately 359 ha of riparian vegetation as defined by the EHP vegetation management watercourse map. The EIS contains a Biodiversity Offset Strategy which describes the offsets that will be provided for impacts on these MSES.

The EIS describes a number of management plans and procedures that will be put in place to limit impacts of the project on flora and fauna, including a Biodiversity Management Plan, Feral Animal and Weed Management Plan, Species Management Plan (prepared in accordance with the NC WM Regulation) and a Subsidence Management Plan.

Black-throated Finch (white-rumped subspecies)

Storr's Monitor

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AQUATIC ECOLOGY

This EIS includes a detailed aquatic ecology assessment that involved multi-season aquatic biology surveys. The project site is located in the headwaters of the Belyando River catchment and site drainages are highly ephemeral. There are no watercourses (as defined by the *Water Act 2000*) on the project site. Site drainages are in the form of highly ephemeral drainage lines which flow only during and shortly after rainfall.

There is very limited aquatic habitat in the project site. Aquatic habitat is restricted to remnant pools that form along the ephemeral drainage lines after rainfall, along with two seasonal wetlands and two artificial farm dams (Figure 8). One of the seasonal wetlands, namely the northern seasonal wetland, has been mapped as a High Ecological Significance (HES) Wetland by EHP. The northern seasonal wetland has been created by rainfall accumulating during the wet season. The construction of a nearby farm dam also helps to retain water in this area. The northern seasonal wetland is not dependent on groundwater recharge.

No listed (NC Act or EPBC Act) aquatic flora and fauna species were found utilising the project site and, based on a review of habitat requirements and known species distribution, none are expected to occur. No listed aquatic communities were identified within the project site. The project site does not contain any fish habitat areas, aquatic reserves or habitat areas declared under state provisions.

Overall, the project is not considered likely to have any significant impacts on aquatic ecology or stygofauna.

The northern seasonal wetland is located above the Northern Underground and will be subject to subsidence. The northern seasonal wetland is mapped by the EHP as a HES wetland and consequently it will be necessary to provide offsets under the *Environmental Offsets Regulation 2014* in the event the project has a significant, residual impact on the wetland. The need for offsets will be determined prior to any subsidence of the wetland based on detailed mine planning and subsidence predictions for the area.

The EIS describes a number of management plans and procedures that will be put in place to limit impacts of the project on aquatic ecology, including a Biodiversity Management Plan, Feral Animal and Weed Management Plan, Species Management Plan (prepared in accordance with the NC WM Regulation) and a Subsidence Management Plan.

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MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

The project was declared a controlled action on 30 October 2014 and requires approval under the EPBC Act before it can proceed. The controlling provisions are:

- Listed threatened species and communities (Sections 18 & 18A);
- Listed migratory species (Sections 20 & 20A); and
- A water resource, in relation to coal seam gas development and large coal mining development (Section 24D).

No threatened ecological communities or threatened flora species listed under the EPBC Act were recorded or are considered likely to occur within the project site.

The following threatened fauna species listed under the EPBC Act were recorded on the project site:

- Squatter Pigeon (southern subspecies) (*Geophaps scripta scripta*) (vulnerable);
- Black-throated Finch (white-rumped subspecies) (*Poephila cincta cincta*) (endangered); and
- Koala (*Phascolarctos cinereus*) (vulnerable).

The Australian Painted Snipe (*Rostratula australis*) (endangered) was assessed as having a moderate potential to occur on the project site.

In addition, three migratory species listed under the EPBC Act were recorded on the project site, namely the Eastern Great Egret (*Ardea modesta*), Rainbow Bee-eater (*Merops ornatus*) and Satin Flycatcher (*Myiagra cyanoleuca*). Two additional migratory species were assessed as having a high potential to occur within the project site, namely the Fork-tailed Swift (*Apus pacificus*) and Cattle Egret (*Ardea ibis*). The Latham's Snipe (*Gallinago hardwickii*), was also assessed as having a moderate potential to occur within the project site.

The EIS includes an assessment of potential impacts on these species and concluded that the project will give rise to potentially significant impacts on the Squatter Pigeon (southern subspecies), Black-throated Finch (white-rumped subspecies) and Koala. The EIS contains a Biodiversity Offset Strategy which describes the offsets that will be provided for impacts on these species. The EIS does not predict any significant impacts on the Australian Painted Snipe or on any migratory species.

The EIS describes a number of management plans and procedures that will be put in place to limit impacts of the project on flora and fauna, including a Biodiversity Management Plan, Feral Animal and Weed Management Plan, Species Management Plan and a Subsidence Management Plan.

The other controlling provision for the project is "*A water resource, in relation to coal seam gas development and large coal mining development*". An overview of the assessment of impacts on water resources is provided in the following groundwater and surface water sections.

Squatter Pigeon (southern subspecies)

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GROUNDWATER

The EIS groundwater assessment included field investigations, the installation of monitoring bores, and the development of a 3D numerical groundwater model to predict the impact of mining during the operational and post-mining phases. The groundwater assessment also considered the potential cumulative impacts with the adjacent Carmichael Coal Mine Project.

The local groundwater regime is summarised in Figure 9, along with a schematic of the regional hydrogeology. Groundwater is not widely used in the region because of low yields and variable water quality.

Field investigations confirmed that the minor drainage features and overland flow paths present within the project site and downstream catchment are characterised by rock channels or exposed Tertiary sediments. Extensive, deep alluvial deposits and associated shallow groundwater are therefore absent from the project site and surrounding area.

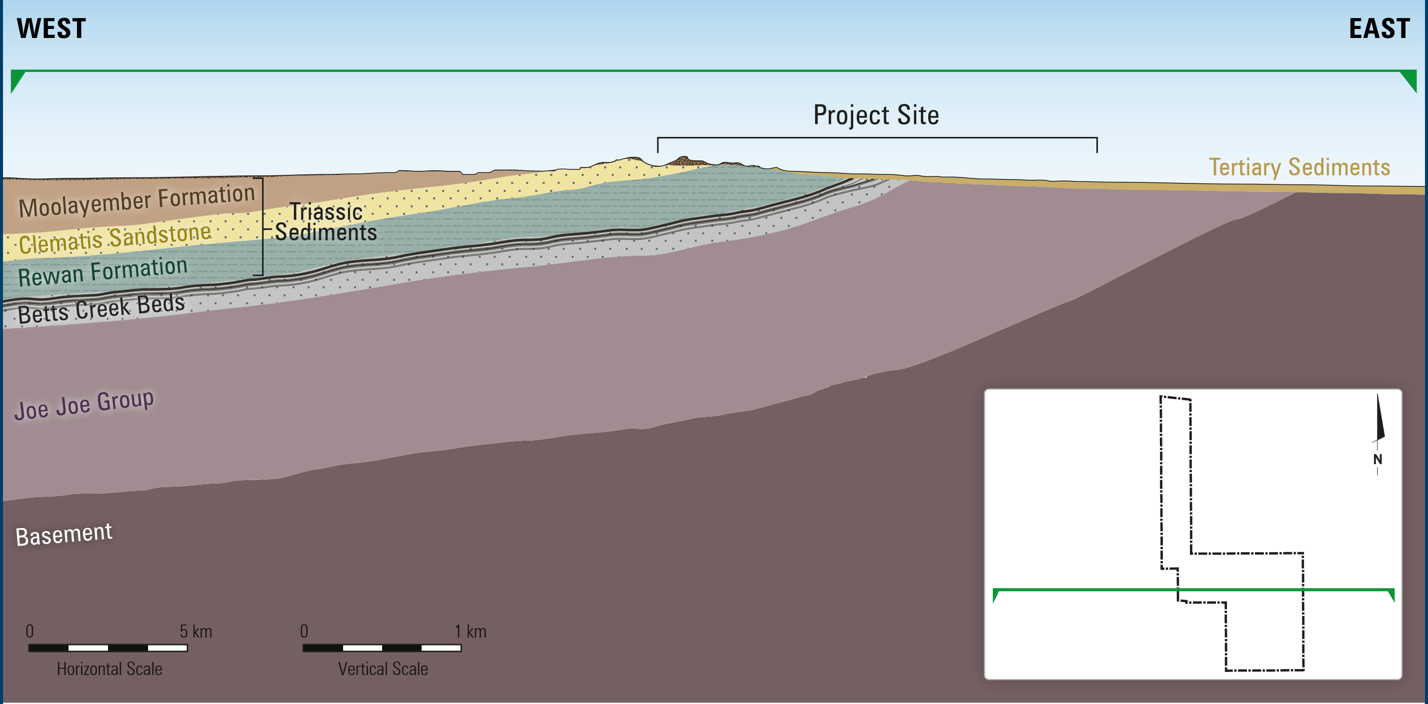
Groundwater use in the region is sporadic and dispersed over a wide area due to the generally significant depth to groundwater and typically low yields. Water quality is variable, but is generally suitable for stock watering.

The groundwater assessment considered impacts on the groundwater regime due to open cut and underground mining; as well as the effects of sub-surface cracking in areas that are subject to longwall mining. The groundwater assessment includes detailed predictions of groundwater depressurisation. Key conclusions of the assessment in relation to impacts as a result of groundwater depressurisation are as follows:

- The project will not impact on any springs, surface drainage features or groundwater dependent ecosystems as a result of groundwater drawdown.
- Depressurisation will result in some water take from the Great Artesian Basin (GAB) aquifers. However, the predicted water take during the operations phase is relatively minor when compared to the estimated total groundwater storage within the GAB. No short term or long term loss of recharge to the GAB is predicted as a result of the project.
- During mining operations the project is not predicted to impact on bores that are located beyond the project site. Private bores within the project site will be managed through land access arrangements with landholders. As part of mine closure planning, the proponent will enter into agreements with landholders of any bores potentially impacted by drawdown post mining.

Potential impacts on groundwater quality, including potential for contamination from the storage of hydrocarbons and potential seepage from the TSF and PSWSF, were considered in the EIS. Hydrocarbons will be stored in accordance with the procedures described in the EIS that are designed to prevent contamination of groundwater. Groundwater contamination from the TSF and PSWSF is not considered to be a significant risk because these facilities will be constructed on a low permeability foundation with a seepage collection system. In addition, geochemical testing has confirmed that any leachate will be pH neutral to slightly alkaline, with low levels of salinity comparable to that of natural underlying groundwater. Predicted cumulative impacts with the proposed Carmichael Coal Mine are limited to the area where the two projects adjoin. There are no significant impacts predicted as a result of cumulative groundwater depressurisation in this area. A groundwater monitoring program was established during the preparation of the EIS and will continue over the life of the project. The monitoring program is designed to confirm the groundwater impacts are as predicted and will identify any unexpected impacts.

FIGURE 9 REGIONAL HYDROGEOLOGY CROSS SECTION



	TERTIARY SEDIMENTS	TRIASSIC SEDIMENTS	PERMIAN BETTS CREEK BEDS
Overview	Highly weathered detrital deposit comprising claystone and weakly indurated sandstone and siltstone. Distributed over low lying areas either side of Darkies Range. Generally thin or absent on the elevated ridge of Darkies Range. Range in thickness across the project site from 0 to 60 m. A water table forms within these sediments in the south-east of the project site and extends east towards the Belyando River.	The Moolayember Formation is the youngest Triassic formation in the vicinity and comprises siltstone, mudstone and sandstone. This unit subcrops to the west of Darkies Range within 7 km of the project site. The Clematis Sandstone is a sandstone unit, with minor interbeds of siltstone and claystone. The Clematis Sandstone is a key aquifer of the GAB and outcrops within the project site. The Clematis Sandstone is dry and unsaturated throughout the project site, except where faulted in the north. West of the project site, the Clematis Sandstone is overlain by the Moolayember Formation, a unit of the GAB. The Clematis Sandstone is underlain by the Rewan Formation, a recognised regional aquitard.	Low permeability coal measures that include the target coal seams for the project. Groundwater storage is typically within fractures and fissures within individual coal seams. The Betts Creek Beds are underlain by the Joe Joe Group and the basement formation of the Drummond Basin.
Recharge	In elevated areas, recharge is diffuse and limited to sporadic rainfall events over small catchment areas. In the lower lying areas beyond Darkies Range, recharge is expected to be enhanced as the topography transitions from the sloping ridge to flatter plains.	The deep localised water table in the vicinity of Darkies Range indicates a low rate of groundwater recharge from infiltration of direct rainfall where the Clematis Sandstone and Rewan Formation outcrop. Elsewhere, recharge is diffuse and limited to sporadic rainfall events	Recharged through weathered zone underlying Tertiary sediments. Limited recharge from Darkies Range via overlying outcropping Triassic units.
Discharge	Discharge is predominantly to the Belyando River. Groundwater is unlikely to provide any baseflow to surface water in the vicinity of the project site, given the depth to groundwater and distinct ephemeral nature of the surface water systems.	Limited discharge into overlying formations and Lake Buchanan.	Limited discharge into overlying formations.
Water Use and Quality	Fresh to slightly brackish water suitable for use as cattle watering supply.	Clematis Sandstone shows moderate yields of slightly brackish water typically used as cattle watering supply. Moolayember Formation shows lower yields of slightly brackish to 'salty' water typically used as cattle watering supply.	Low yields of slightly brackish to brackish water typically used as cattle watering supply.

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SURFACE WATER

Surface Water

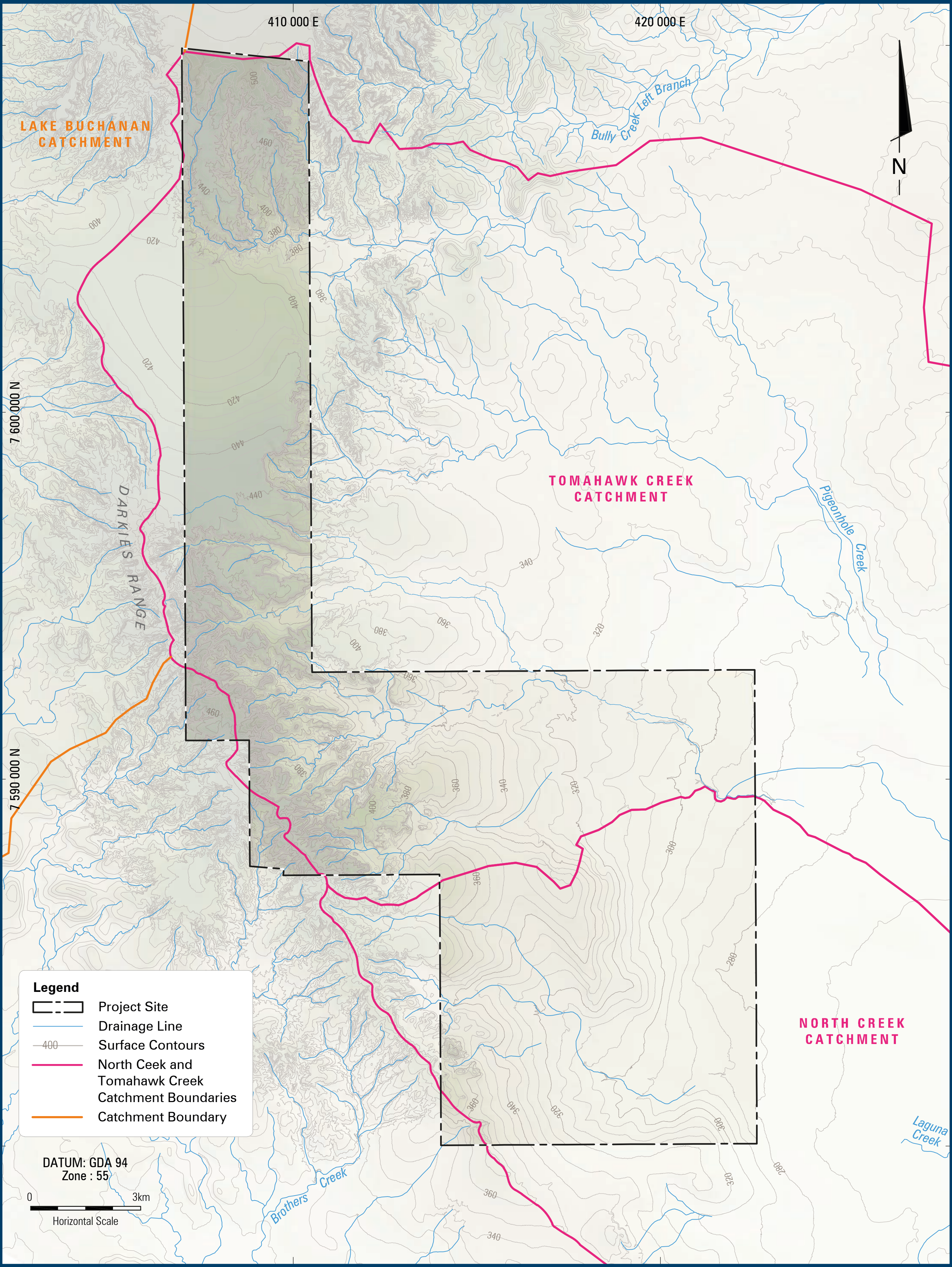
The project site is located within the Belyando Basin, approximately 255 km upstream of the Burdekin Falls Dam. The majority of the project site is drained by the headwaters of Tomahawk Creek and North Creek (Figure 10). These creeks flow to the south-east to the Belyando River downstream of the project site. The Belyando River is an ephemeral, regionally significant watercourse that enters the Suttor River upstream of the Burdekin Falls Dam. The site is located at the head of the Tomahawk and North Creek catchments and site drainage is therefore highly ephemeral. There are no major waterways traversing the project site.

Environmental values for the existing surface water environment in the vicinity of the project site were derived from the Queensland Government's *Environmental Protection Policy (Water)* (2009) and Queensland Water Quality Guidelines and assessed through both field observations and water quality analysis.

The existing surface water environment can be summarised as slightly to moderately disturbed by human activities (including agriculture) with naturally high sediment loads arising primarily from hillslope erosion.

North Creek at Moray Bulliwalla Road, downstream of project site

FIGURE 10 LOCAL CATCHMENT SETTING



Mine Water Management

The EIS proposes management strategies for waters generated by the project. These strategies are dependent on the quality of the water and are designed to prevent any adverse impacts on downstream surface water values. The requirements to maximise the reuse of mine-affected water for water supply, minimise the demand for external water supply and minimise the risk of uncontrolled discharge of any mine-affected water from the project site were also key considerations in the selection of appropriate water management strategies.

The project water management system has been designed to manage each of the water types generated by the project. These include:

- Pit water from underground and open cut mining areas;
- Return water from the TSF and PSWSF;
- Runoff from areas disturbed by project activities including overburden emplacement areas and mine infrastructure areas;
- Runoff from areas affected by mine subsidence; and
- Runoff from areas undisturbed by project activities.

The EIS includes a conceptual site drainage plan that includes the following:

- Diversion of clean runoff from undisturbed areas around areas disturbed by mining activities to allow it to drain from the site;
- Control of suspended sediment in site drainage water to prevent downstream sedimentation;
- Containment of mine-affected water in on-site mine water storages for use as mine water supply and release of any excess mine-affected water under controlled conditions in accordance with EHP's model EA conditions;
- Provision of an adequate level of flood protection for mine infrastructure and the open cut pit; and
- Establishment of a free-draining post mining landform beyond the final void.

Drainage infrastructure including diversion drains, collection drains, sediment dams and sediment traps will be constructed progressively as the operations expand over the life of the mine.

Hydraulic modelling of the mine drainage system was conducted for the 1 in 2 and 1 in 50 Annual Exceedance Probability flood events in order to assess surface water impacts on downstream properties and stream geomorphology. The predicted changes in flood levels and distribution will not impact on any structures or property, and in most cases will not be discernible when compared to existing conditions due to the wide shallow nature of the flow paths. The grazing land use on the downstream properties is also not sensitive to the predicted minor and localised changes in flood levels and flow distribution. No significant flood impacts are therefore predicted.

The water management system involves the use of mine-affected waters as mine water supply, and an external raw water supply to meet high quality water supply requirements and make up any shortfall in the site water balance. An operational simulation model has been used to assess the project water balance across a range of climatic conditions over the life of the project. The modelling results indicate a significant overall water deficit for the project and the need for a significant external water supply. There are a number of parties currently developing water supply options for the Galilee Basin coal mines. The current preferred water supply option would be to gain an allocation from a piped water supply from one of two schemes being proposed to harvest water from the Cape River or the Belyando/Suttor River system.

The modelling results also indicate that the mine water management system has adequate capacity to contain mine affected water generated by the project with a low probability of uncontrolled discharge. During extended rainfall periods the open cut pit will collect significant volumes of rainfall runoff and this will result in a surplus of mine-affected water within the mine water management system. Following such events, in order to dewater the open cut pits and allow continuing production, it will be necessary for accumulated pit water to be discharged from site under controlled conditions. A Site Water Management Plan will be developed for the project. It will include surface water and mine water balance monitoring programs.

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CLIMATE

Climatic data has been collected from two Bureau of Meteorology meteorological stations located in proximity to the site. The closest station to the project site is located approximately 12 km to the south-west on the Carmichael property and has collected rainfall data since 2003. The Clermont Post Office meteorological station which, although being located approximately 180 km to the south-east of the project site, is the nearest weather station that records additional meteorological parameters. It has collected rainfall, temperature and humidity data from 1870 until 2011 when it was decommissioned.

Central Queensland has a sub-tropical continental climate characterised by high variability in rainfall, temperature and evaporation. The region can experience droughts, floods, heatwaves and frosts. In general, winter days are warm and nights are cool, while summer days are hot and nights are warm. The seasonal average maximum temperature measured at Clermont is 34.8 °C in summer and 25.3 °C in winter. Seasonal average minimum temperatures range from 21.6 °C in summer to and 6.7 °C in winter.

Rainfall is summer dominant with almost half of the average annual rainfall occurring from December to February due to storms and tropical lows associated with cyclones. Average monthly rainfall ranges from 15 mm in May to 127 mm in January with an annual average rainfall of 525 mm. Relative humidity is generally 20% higher in the morning compared to the afternoon. The highest monthly average relative humidity was recorded in February for both morning and afternoon values (71% and 47%, respectively).

Winds are typically light to moderate, originating predominantly from the north-east to the south-east. The most prevalent wind speeds experienced are moderate winds ranging from 2 to 5 m/s, which occur 59% of the time. Light winds ranging between 0 and 2 m/s speeds occur 32% of the time, strong winds greater than 5 m/s, occur only 9% of the time.

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AIR QUALITY

The EIS air quality assessment included review of background air quality data, estimation of emission rates from mining activities and the power station, and dispersion modelling to estimate air quality in the vicinity of the project site. Air quality objectives relevant to mining activities have been developed from the Queensland Government's *Environmental Protection Policy (Air)* (2008) (EPP Air). These criteria are provided in Table 3.

Air quality objectives relevant to emissions from the power station were also developed, based on the following:

- *Approved methods for the modelling and assessment of air pollutants in NSW* (NSW DEC, 2005);
- *Texas Commission on Environmental Quality Effects Screening Levels 2009* (TCEQ, 2009); and
- *Ambient Air Quality Criteria, 2008* (OME, 2008).

The closest homestead to the project site is approximately 7.2 km to the west. The air quality assessment concluded that predicted dust levels will be within applicable ambient air quality objectives at all sensitive receptors.

The assessment also concluded that, due to the significant distance between the underground mining areas and the closest sensitive receptors, potential odour impacts from underground mine ventilation are extremely unlikely.

An assessment of the potential cumulative air quality impacts of the project with the proposed Carmichael Coal Mine and the adjacent Moray Power Project was also undertaken. The assessment concluded that the project will not have a significant contribution to any cumulative air quality impacts.

An assessment of greenhouse gas emissions was undertaken consistent with the guidance provided in the National Greenhouse Accounts and the Greenhouse Gas Protocol. The EIS provides annual predicted greenhouse gas emissions for the project. Greenhouse gas emissions from the project will be predominantly due to the operation of the power station as well as the consumption of diesel fuels and fugitive emissions of coal seam gas. Any reduction in the significant energy requirements for the project will result in decreased GHG emissions. The EIS outlines a number of greenhouse mitigation strategies that are being evaluated for the project.

TABLE 3 AMBIENT AIR QUALITY OBJECTIVES

PARAMETER	AVERAGING PERIOD	VALUE
TSP	Annual	90 µg/m³
PM_{10}	24-hour	50 µg/m³ *(with five exceedances per annum permitted)*
$PM_{2.5}$	24-hour	25 µg/m³
	Annual	8 µg/m³
Dust Deposition Rate	Annual	120 mg/m²/day

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NOISE AND VIBRATION

A detailed noise assessment was undertaken and included assessment of predicted noise levels resulting from the mining operations, low frequency noise emissions, construction noise, road traffic noise, aircraft noise, and blasting impacts. Potential cumulative noise impacts with the proposed Carmichael Coal Mine were also assessed.

The noise assessment concluded that predicted noise levels and blast effects will be below the relevant noise criteria at all sensitive residential receptors.

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VISUAL AMENITY

A visual impact assessment was undertaken to determine the impact of the project on the visual quality and character of the surrounding area.

The local visual landscape is dominated by grazing land and remnant woodland vegetation. A well vegetated ridgeline known as Darkies Range is a dominant feature in the landscape and runs in a roughly north to south alignment through the western portion of the project site.

The main potentially visible elements of the project include the elevated overburden emplacement areas and significant mine infrastructure such as CHPP, rail loop and train loading facilities, workshops, mine waste storage facilities, workforce accommodation village and the power station stacks.

Visual receptors identified in the vicinity of the project site include a number of isolated rural residences. The closest residence is approximately 7.2 km from the project site.

The project will also potentially be visible from Elgin-Moray Road and Moray-Carmichael Road which are both unsealed local government roads that provide the primary access from the Gregory Developmental Road to the project site. They are typically utilised by local rural residents and coal exploration related traffic, and are not common routes for tourists.

The visual assessment concluded that the visual impact on sensitive receptors, including residential receptors and users of the local road network, would be low. The visual impact is reduced by the fact that the majority of visual receptors will have limited views of the mine due to screening by intervening topography and/or vegetation, and/or the extended viewing distances.

Access track in southern area of project site

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SOCIO-ECONOMIC IMPACT ASSESSMENT

Social and economic assessments, integrated with a comprehensive stakeholder consultation program, were undertaken for the project. This enabled the identification of community and social issues associated with the project and the development of strategies to address these issues.

The social assessment considered the impacts associated with the project, particularly impacts (both positive and negative) due to the project workforce. Due to the remote location of the project site, the condition of the surrounding regional road network and the size of the workforce required for the project, it is anticipated that the majority of workers will be employed on a non-resident, long distance commuting basis and will be housed in an on-site accommodation village.

The social assessment considered the following broad areas: employment and labour market dynamics, regional development, employee health and wellbeing, community health and wellbeing, community infrastructure and services, and social amenity. The project will give rise to positive and negative impacts within these broad areas.

The positive impacts of the project relate to the strengthening of the local and regional economies through:

- Creation of significant, long-term employment opportunities, including Indigenous employment opportunities.
- Skills enhancement and training opportunities.
- Increased supply chain opportunities.
- Increased economic activities.
- Increased real wage.
- Resident population growth in regional centres.
- Improved infrastructure and services for the surrounding area.

Potential negative impacts are predicted to include the following:

- Labour draw in response to the labour requirements of the project and the existing and anticipated skill shortages of relevance to the project.
- Employee health implications related to the non-resident commuting workforce.
- Increased traffic movements and reduced road safety.
- Increased demand on emergency services.
- Change in rural character.

A series of management plans will be developed to enhance the social and economic benefits of the project and to limit the potential adverse social impacts on the local community. These action plans relate to project workforce recruitment including Indigenous participation, training and skills development, local industry participation, and employee wellbeing. The proponent will also report on an annual basis to relevant stakeholders from the commencement of the construction phase and for two years following the commencement of mining operations. The annual report will:

- Describe the actions to inform the communities of the local area about project impacts and show that community concerns about project impacts have been taken into account when reaching decisions;
- Describe the actions to enhance local and regional employment, training and development opportunities; and
- Describe the actions to avoid, manage or mitigate project-related impacts on local community services, social infrastructure and community safety and wellbeing.

The key economic benefits of the project include:

- Direct employment of up to approximately 3,900 persons during the construction phase, and up to approximately 3,400 persons during the operations phase;
- Creation of substantial indirect employment in Queensland during the construction and operations phases;
- The addition of up to $1.5 billion annually to the gross state product of Queensland; and
- The payment of an annual average of $188 million to the Queensland Government in the form of royalty payments.

Mosman Street, Charters Towers

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TRAFFIC AND TRANSPORT

Road Traffic

The key roads that will be used by the project traffic are the Flinders Highway, Gregory Developmental Road, Elgin-Moray Road and Moray-Carmichael Road (Figure 11). The Peak Downs Highway may also be used to a much lesser extent. A new mine access road will connect the project site to the Moray-Carmichael Road. An indicative alignment of the access road is shown on Figure 11.

A detailed assessment of traffic and transport impacts was completed which considered the impacts of traffic generated by the project on affected public roads and intersections. The traffic study provides conservative worst-case project traffic volumes and estimates of the increase in total traffic volumes for affected public roads.

The project's potential impact on intersections was considered at the following locations:

- Flinders Highway/Gregory Developmental Road intersection;
- Gregory Developmental Road/Elgin-Moray Road intersection (point of access to the State-controlled road network); and
- Proposed Moray-Carmichael Road/Project China Stone Mine Access Road intersection.

A detailed analysis of these intersections indicated the following:

- The Flinders Highway/Gregory Developmental Road intersection will continue to meet industry standard performance thresholds and will continue to provide an appropriate level of safety irrespective of the presence of project traffic demands.
- Improved turn treatments of the Gregory Developmental Road/Elgin-Moray Road intersection should be provided at the intersection to safely accommodate future traffic volumes. It is noted that upgrade of the intersection to include protected turn lane treatments is required as part of the development of the Carmichael Coal Mine and Rail Project (CCM&RP) which is anticipated to precede Project China Stone.
- The provision of a basic right turn treatment and a basic left turn treatment at the new mine access road intersection would provide an appropriate level of safety and operational performance.

A significance assessment was undertaken to identify if the additional heavy vehicle movements generated during the project's construction phase and operations phase will have a significant impact on the State-controlled road network. Potentially significant impacts on pavement rehabilitation were identified on sections of the Flinders Highway and Gregory Developmental Road during the construction and operations phases. Potentially significant increases in pavement maintenance impacts have been identified on sections of the Townsville Port Road, Flinders Highway, Gregory Developmental Road and the Peak Downs Highway. It is noted that in many cases the duration of significant impact is limited to the construction phase only. The project's pavement rehabilitation impact and pavement maintenance impact will need to be recalculated prior to the commencement of construction based on confirmed pavement loadings and traffic estimates associated with the CCM&RP. This will enable the accurate quantification of any monetary contribution towards pavement rehabilitation and pavement maintenance activities in accordance with the TMR guideline.

Elgin-Moray Road, east of the project site

Gill Street, Charters Towers

An assessment of the crash data for the road network indicated no obvious trends that could potentially be exacerbated by the increase in traffic associated with the project.

Rail Traffic

Coal from the project is proposed to be transported by rail to the Abbot Point Coal Terminal located at the Port of Abbot Point. An on-site rail loop and train loading facility will connect to a future off-site rail spur connecting the mine site to a future rail line from the Galilee Basin to the Abbot Point Coal Terminal. The proponent will be responsible for developing the off-site rail spur connection. The rail line connecting the Galilee Basin to the Abbot Point Coal Terminal will be developed by another party. The alignment of the preferred rail line from the Galilee Basin to the Abbot Point Coal Terminal is not certain at this stage and consequently it is not possible to confirm the location of the off-site rail spur connection at this stage. The off-site rail spur would be subject to a separate environmental impact assessment and approval. These will be progressed once the alignment of the rail spur can be determined.

At its peak production capacity, the project will be serviced by an average of six coal trains per day, up to a peak of eight trains per day.

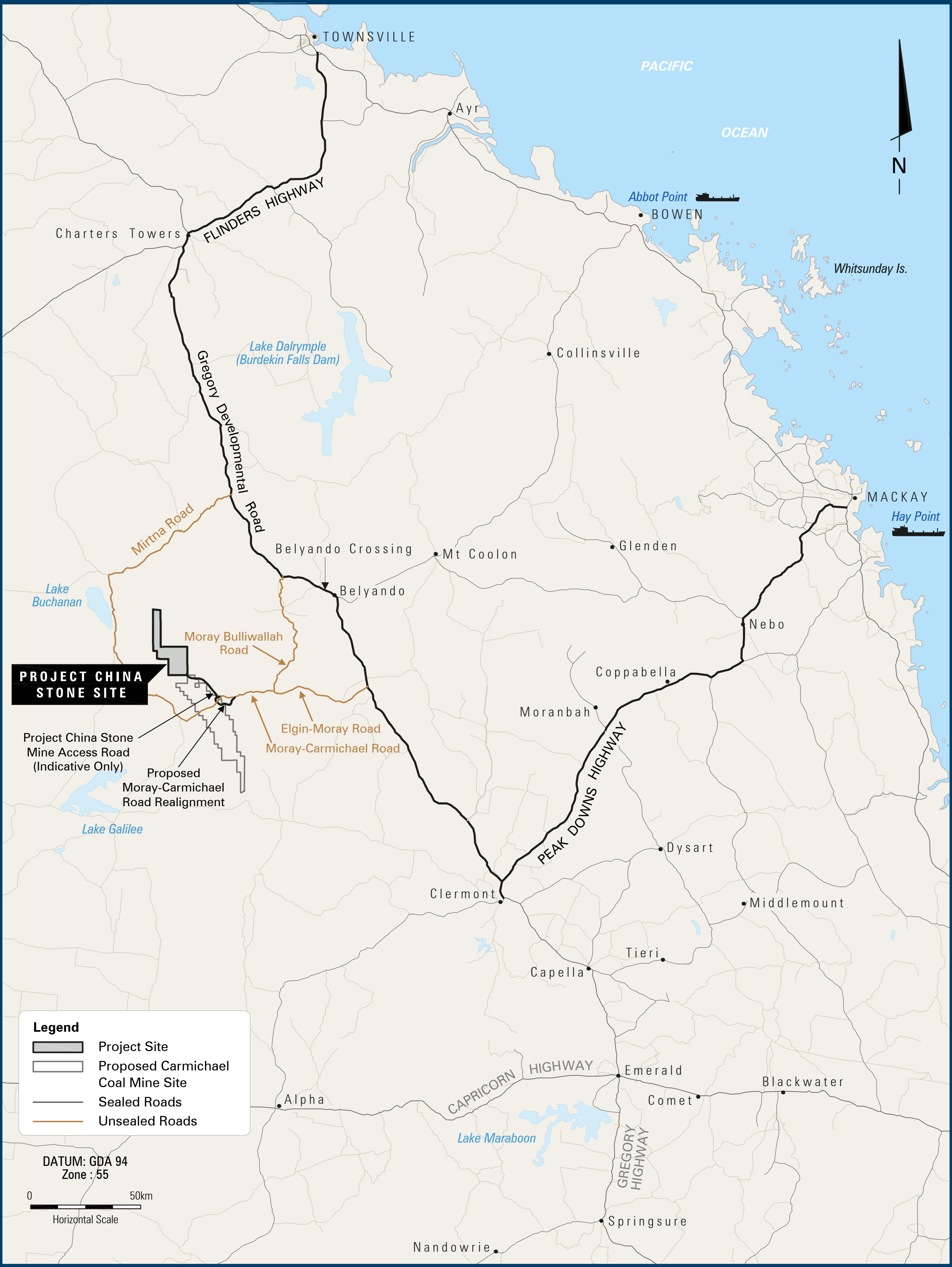
Air Traffic

A private airstrip will be constructed in the south-eastern part of the project site, for the transport of the mine workforce and materials. Construction of the airstrip is scheduled to be completed prior to the end of Project Year 1. The airstrip facilities will include baggage handling and passenger security.

The airstrip will be designed to cater for a range of aircraft, including Boeing 737s, Airbus 320s and Bombardiers. Current planning estimates approximately 40 flights per week will be required during operations from a range of potential coastal centres including Brisbane, Gold Coast, Wide Bay, Townsville and Cairns.

The airstrip will be designed, constructed and operated in accordance with CASA regulations and guidelines. Project air traffic control will be coordinated with the airports at the workforce source locations. Project air traffic control will also be coordinated with the Carmichael Coal Mine airstrip.

FIGURE 11 REGIONAL ROAD NETWORK



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CULTURAL HERITAGE

The EIS considers Aboriginal heritage in relation to the requirements of the *Aboriginal Cultural Heritage Act 2003* and includes a detailed assessment of non-Indigenous heritage values on the project site.

No declarations in relation to Aboriginal heritage have been made under Commonwealth legislation for the project site and there are no sites listed on Commonwealth heritage lists. The Wangan and Jagalingou People have been identified as the Aboriginal party for the project in accordance with the *Aboriginal Cultural Heritage Act 2003*. The proponent has put in place with its consultant the process to initiate a Cultural Heritage Management Plan (CHMP) with the Wangan and Jagalingou People in accordance with this Act. The CHMP is required to be finalised prior to the commencement of construction.

The non-Indigenous heritage assessment included a desktop review (including interviews with landholders and local residents) to identify heritage themes in the region and to predict the locations and types of items of cultural heritage potentially located on the project site. A field inspection was then undertaken to locate and describe any cultural heritage.

The non-Indigenous heritage assessment did not identify any sites of national, state or local heritage significance on the project site. The proponent will implement procedures to mitigate impacts in the unlikely event that previously unrecorded sites of non-Indigenous cultural heritage significance are located during ground disturbance associated with the project.

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NON-MINING WASTE MANAGEMENT

The main wastes anticipated to be generated by the project include:

- Green waste;
- Scrap metal;
- Waste oils, other hydrocarbons and miscellaneous chemicals;
- Batteries and tyres;
- Sewage; and
- General waste.

The proponent will develop and implement a waste management system for the project which will meet the *Waste Reduction and Recycling Act 2011*, the *Waste Reduction and Recycling Regulation 2011*, the *Environmental Protection (Waste Management) Regulation 2000*, the EP Act and the *Environmental Protection Regulation 2008*.

The waste management system will provide for the identification of waste types; commit to the use of licensed waste transport contractors; and outline the process for tracking of relevant regulated wastes. The principles of cleaner production will form an important component of the project's waste management system. The waste management system will include design and management of an on-site landfill to dispose of general wastes in accordance with the Queensland Government *Guideline - Landfill Siting, Design, Operation and Rehabilitation, EM2319, Version 2* (EHP 2013).

A site history of the project site, compiled in accordance with the *Contaminated Land Assessment Guideline* (EHP 2014), revealed no properties on the project site that are listed on the Contaminated Land Register or the Environmental Management Register, and there are no known historical or existing contaminated sites within the project site.

The project includes the following Notifiable Activities (NAs):

- 1 Abrasive Blasting;
- 7 Chemical Storage;
- 8 Coal Fired Power Station;
- 14 Engine Reconditioning Works;
- 20 Landfill; and
- 29 Petroleum Product or Oil Storage.

The risk of land contamination from project activities, including NAs, will be reduced through appropriate design and construction of the facilities and post-mining rehabilitation.

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HAZARD AND RISK

The introduction of a mine or industrial facility to an area carries potential hazards and risks.

A suite of legislation exists in relation to occupational health and safety at mine sites. This is supplemented by codes of practice issued under regulations and Australian Standards that represent best practice for managing risks.

The proponent will implement a Safety and Health Management System (SHMS), which will meet the requirements of appropriate legislation and standards, to address the construction, operations and decommissioning phases of the project. The SHMS will include operational hazard analysis, regular hazard audits, fire safety, emergency response plans, qualitative risk assessment, and construction safety. The proponent will develop a Hazard, Defect and Incident Procedure to monitor conformance with the SHMS. Audits, inspections, reviews and independent contributions will all be used to identify corrective actions as part of the process of continual improvement in the SHMS.

A Preliminary Hazard Analysis (PHA) has been undertaken to assess the level of risk that the project presents to surrounding land uses and community values. In identifying hazards associated with the project, consideration has been given to project activities and also natural and technological events, and malicious acts. The highest risks derived under the PHA relate to loss of containment, combustion of dangerous goods, catastrophic failure of the power station, aircraft crashes and bushfires. These hazards have moderate to major consequences but generally have a low likelihood of occurrence, resulting in medium to significant risks.

The overall risk profile for the project assessed by the PHA is low due to the controls that have been included within the current design, the proposed SHMS development and the remoteness of the site in relation to populated areas and built infrastructure.

Ongoing consultation will be undertaken with local and regional representatives from the emergency services in relation to the management of hazard and risk. In addition, consultation with key stakeholders will be undertaken as part of the emergency preparedness and response planning, including consultation with local and regional representatives from the emergency services.

In the interests of ensuring that the emergency services are prepared should they be required to respond to an incident at the project site, the proponent will provide relevant information as it becomes available.

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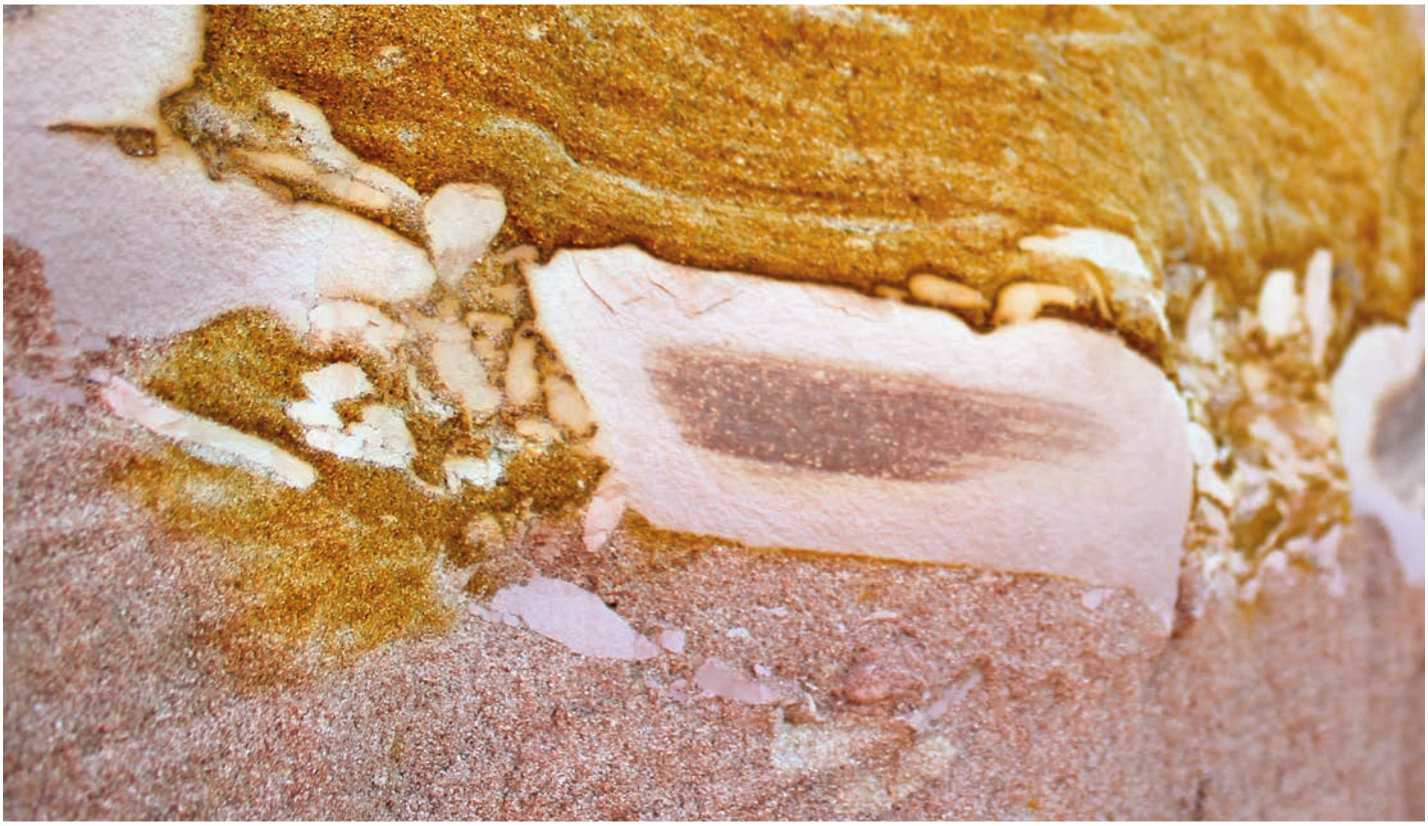
CUMULATIVE IMPACTS

Cumulative impact assessments have been completed as a component of each of the relevant environmental studies within the EIS. The cumulative impact assessments include the impacts from the proposed Carmichael Coal Mine and, where relevant, the Moray Power Project which is proposed to provide power to the Carmichael Mine. These projects are both currently in the approval phase. The Carmichael Mine site adjoins the project site to the south-east and the Moray Power Project is located approximately 23 km to the south-east of the project site, adjacent to the Carmichael Mine site. The two mines and power station are expected to be operational over a similar time period.

Overall, the project is not anticipated to contribute to any significant adverse cumulative impacts. Where necessary, appropriate management measures have been identified for any potential adverse cumulative impacts with the proposed Carmichael Coal Mine. The proponent will consult with Adani Mining Pty Ltd (the proponent for the proposed Carmichael Coal Mine) to ensure the effective management of potential cumulative impacts including impacts on air quality, land use, traffic and transportation and socio-economic impacts. No significant adverse cumulative impacts are predicted in association with the Moray Power Project.



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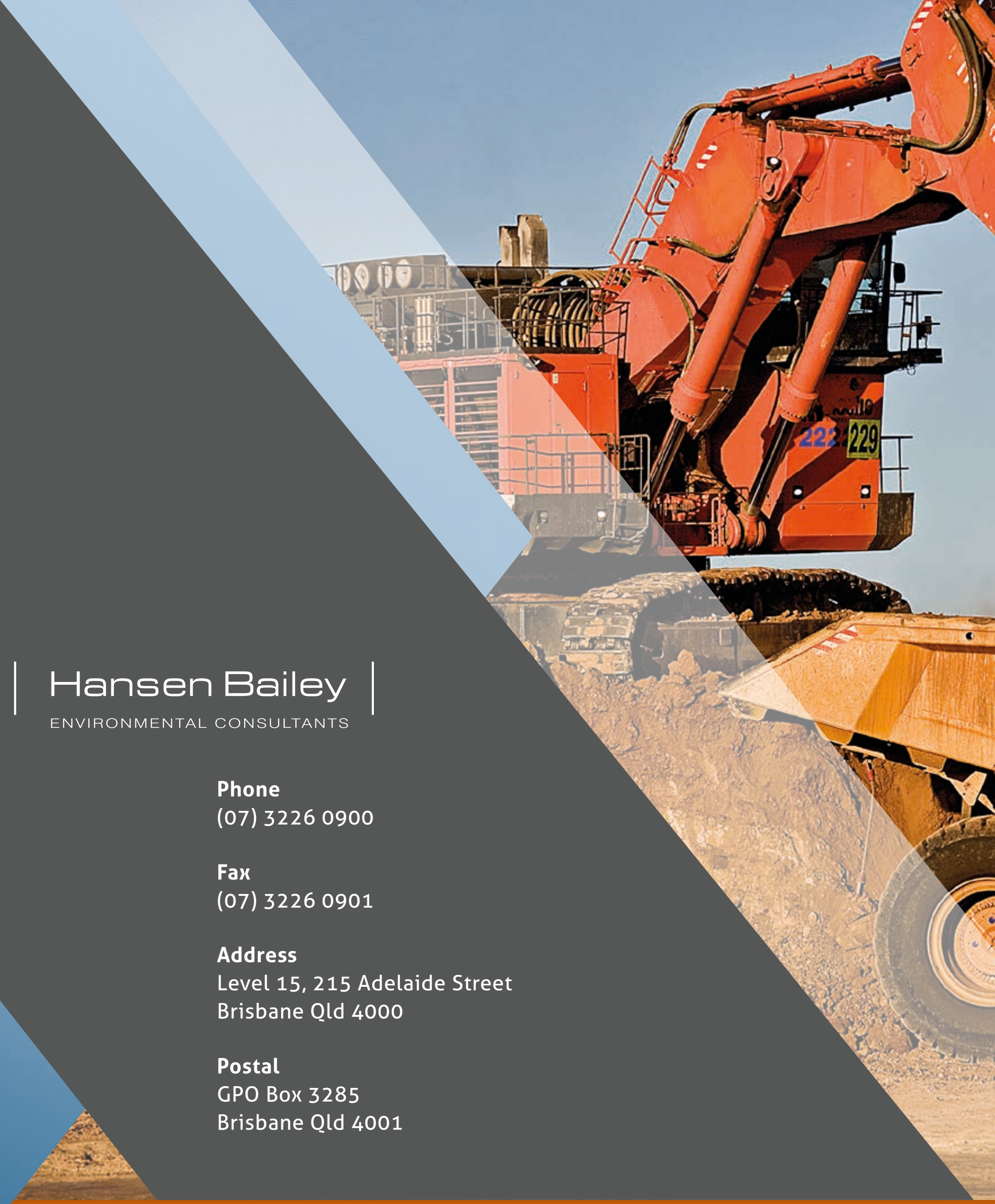
ENVIRONMENTAL MANAGEMENT

The EIS contains measurable and auditable commitments to environmental management practices for the project. The implementation of these commitments will ensure that the project is undertaken in accordance with a high standard of environmental management.

The EIS contains a section on environmental management which provides a summary of key environmental management commitments.

Grevillea on project site



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PROJECT CHINA STONE

Project Description

4

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4 PROJECT DESCRIPTION

4.1 INTRODUCTION

This section describes Project China Stone (the project), including the proposed mining activities and mine site infrastructure. Key project alternatives and the project justification are also discussed in this section.

4.2 PROJECT OVERVIEW

The project involves the construction and operation of a large-scale coal mine on a greenfield site in Central Queensland at the northern end of the Galilee Basin (Figure 4-1). The mine will produce up to approximately 55 million tonnes per annum (Mtpa) of Run of Mine (ROM) coal. This equates to approximately 38 Mtpa of thermal coal for the export market. The mine life will be in the order of 50 years.

Coal will be mined using both open cut and underground mining methods (Figure 4-2). Open cut mining operations will involve multiple draglines and truck and shovel pre-stripping. Underground mining will involve up to three operating longwalls. Coal will be washed and processed on site and product coal will be transported from site by rail.

The majority of the mine infrastructure will be located to the east of the open cut mining area (Figure 4-2). It will include Coal Handling and Preparation Plants (CHPPs), stockpiles, conveyors, rail loop and train loading facilities, workshops, dams and a Tailings Storage Facility (TSF) (Figure 4-2). A workforce accommodation village and private airstrip will also be located in the eastern part of the project site.

The project includes the construction and operation of an on-site power station and associated Power Station Waste Storage Facility (PSWSF). The power station will be used for mine power supply and will utilise coal rejects from the mine as feed coal.

The scope of the Environmental Impact Statement (EIS) is limited to the mine site activities and does not include off-lease infrastructure that will be required for the project. Off-lease infrastructure will include port capacity, rail connection to port, mine site access road connection and raw water supply. These will subject to separate environmental impact assessments and approvals. The current preferred option and status of each off-lease infrastructure component are discussed in Section 4.13.

The EIS refers to Project Years, rather than calendar years, with Project Year 1 being the first year of mine construction. Based on current planning, and subject to gaining the necessary project approvals, Project Year 1 is anticipated to be 2016. It is anticipated that open cut coal production will commence in Project Year 3 (2018) after the removal of the initial box cut overburden. Longwall mining will also commence in Project Year 3 following the construction of underground mine access drifts and initial underground mine development works.

4.3 PROJECT SITE

4.3.1 Location

The project site is the combined area of the proposed mining leases and covers an area of approximately 20,000 ha. It is remote, being located approximately 270 km south of Townsville, and 300 km west of Mackay, in Central Queensland (Figure 4-1). Current access to the site is via the Gregory Developmental Road and approximately 130 km of unsealed local government roads (Figure 4-3). The closest townships to the site are Charters Towers, approximately 285 km by road to the north, and Clermont which is approximately 260 km by road to the south-east (Figure 4-1).

The project site is at the north-western limit of the Isaac Local Government Area and adjacent to the southern boundary of the Charters Towers Local Government Area (Figure 4-3).

The proposed Carmichael Coal Mine site adjoins the south-eastern corner of the project site (Figure 4-3).

4.3.2 Natural Features

The south-eastern portion of the project site consists of low-lying, generally flat to undulating woodlands. A well vegetated ridgeline, known as 'Darkies Range', runs in a roughly north to south alignment through the western portion of the site (Figure 4-4).

The project site is located in the Belyando Sub-Basin of the Burdekin Basin. The site is at the head of the local creek catchments and site drainage is therefore highly ephemeral. There are no major waterways traversing the site. Darkies Range forms a catchment divide at the western boundary of the site. The site drains generally to the east through a network of gullies in the steeper areas in the west which transition to broad shallow drainage lines in the flatter areas in the east (Figure 4-5). Site drainage is discussed in detail in Section 13 – Surface Water.

4.3.3 Land Ownership and Land Use

The project site is located within three parcels of crown land that are leased by three separate landholders (Figure 5-4). A stock route traverses the southern part of the project site from south-west to north-east. There are no easements across the project site.

The project site is currently used for cattle grazing and coal exploration. Government mapping shows that there are no strategic cropping areas on the project site. Built infrastructure on the site is limited to stock fencing, unsealed access tracks and stock watering dams.

Section 5 – Land Use provides a more detailed description of the land ownership and use within the project site. The proponent has commenced discussions with the relevant landholders in relation to gaining access to the land for the project.

4.4 COAL, MINERAL AND PETROLEUM TENEMENTS

The project Mining Lease Application areas (MLAs) (MLA 70514, MLA 70515, MLA 70516, MLA 70517 and MLA 70518) were lodged with the Department of Natural Resources and Mines on 3 February 2014.

The MLAs are within EPC 987 which is held by the proponent. The proponent also holds a Mineral Development Licence Application (MDLA 516) over part of the project site. The MDLA was lodged with the Department of Natural Resources and Mines on 10 October 2013.

Table 4-1 lists the coal and petroleum tenements within the project site and Table 4-2 lists the adjoining tenements. There are no mineral tenements within or adjoining the project site.

The exploration program has determined that the coal seams within the project site are essentially devoid of gas. The holders of the overlapping Exploration Permits for Petroleum (ATP 744 and ATP 1044) confirmed in writing, prior to the lodgement of the project MLAs, that they have no objection to the MLAs.

Table 4-1 Coal and Petroleum Tenements within the Project Site

TENEMENT	TENEMENT HOLDER	EIS FIGURE REFERENCE
COAL TENEMENTS		
Mining Lease Applications (MLA)		
MLA 70518	MacMines Austasia Pty Ltd	Figure 4-6
MLA 70517	MacMines Austasia Pty Ltd	
MLA 70516	MacMines Austasia Pty Ltd	
MLA 70515	MacMines Austasia Pty Ltd	
MLA 70514	MacMines Austasia Pty Ltd	
Mineral Development Licence Applications (MDLA)		
MDLA 516	MacMines Austasia Pty Ltd	Figure 4-6
Exploration Permits for Coal (EPC)		
EPC 987	MacMines Austasia Pty Ltd	Figure 4-7
PETROLEUM TENEMENTS		
Exploration Permits for Petroleum (ATP)		
ATP 744	Comet Ridge Ltd	Figure 4-8
ATP 1044	Queensland Energy Resources Ltd	

Table 4-2 Adjoining Coal Tenements

TENEMENT	TENEMENT HOLDER	EIS FIGURE REFERENCE
MLA 70506	Adani Mining Pty Ltd	Figure 4-6
MLA 70489	Waratah Coal Pty Ltd	
MDLA 485	Waratah Coal Pty Ltd	
EPC 926	Vale Coal Exploration Pty Ltd	Figure 4-7
EPC 1483	Matilda Coal Pty Ltd	
EPC 1663	MacMines North Pty Ltd	
EPC 2166	Spinifex Rural Management Pty Ltd	
EPC 1080	Waratah Coal Pty Ltd	
EPC 1105	Waratah Coal Pty Ltd	
EPC 1288	Waratah Coal Pty Ltd	

4.5 GEOLOGY AND RESOURCE UTILISATION

The proponent has undertaken detailed geological investigations related to the project, including detailed assessment of recent and historic exploration geological data. The key geological information relevant to the EIS Terms of Reference is described in this section.

4.5.1 Regional Geology

The regional geology comprises a sequence of three sedimentary geological basins overlying a stable tectonic basement. These basins comprise, from oldest to youngest, the Drummond Basin, the Galilee Basin and the Eromanga Basin. The eastern margins of these basins outcrop in a north-south orientated arc across central Queensland and regionally dip to the west.

The Drummond Basin sediments are seen in outcrops east of the Galilee Basin. The Drummond Basin was laid down during Late Devonian to Early Carboniferous period. It was subjected to deformation at the end of the Early Carboniferous period when the adjacent metamorphic Anakie Inlier Formation was uplifted causing the basin to be folded. The eastern part of the Drummond Basin was also uplifted along with the Anakie Inlier. Together they formed an upland region which, in the Late Carboniferous, started to shed material into the Galilee Basin to the west.

The Galilee Basin evolved during the Late Carboniferous to Early Permian period and comprised three main depocentres, namely the:

- Lovelle Depression in the north-west;
- Koburra Trough in the north-east; and
- Powell Depression in the south.

Sedimentation was not continuous across the Galilee Basin, with intervals of compression, uplift and erosion marked by hiatus. Deposition was initially through quartz-rich braided streams in the Koburra Trough (the deepest depocentre) and extended to other shallower depocentres in the Early Permian. Early Permian sequences in the western parts of the Koburra Trough and Lovelle Depression were predominantly the result of fluvial and lacustrine deposition. Volcanism at this time generated volcano-lithic strata and tuffs in Early Permian formations.

At the end of the Early Permian period, crustal shortening due to east west compressional tectonics resulted in reverse faulting and uplift.

Accelerated erosion following tectonic uplift produced the basin-wide Middle Permian unconformity. A period of thermal relaxation subsidence combined with crustal loading of the adjacent Bowen Basin during late Permian to Middle Triassic deposited extensive sedimentary sequences throughout the basin. During Late Permian the coal bearing Betts Creek Beds were deposited in the north of the Galilee Basin, while the fluvio-deltaic, coastal plain and shallow marine sequences including the Colinlea Sandstone and Bandanna Formations were deposited in the south of the Galilee Basin. The Early Triassic Rewan Formation sequences were deposited by westerly to south westerly drainage systems.

Further uplift was followed by deposition of the quartz-rich Clematis Sandstone in westerly flowing braided streams. This formation was overlain by basin-wide deposition of the lacustrine and fluvial sequences that formed the Moolayember Formation.

Compressional tectonics from the mid-Triassic Hunter-Bowen Orogeny ceased subsidence, curtailed deposition and tilted the basin down to the south-west prior to deposition of the more recent Eromanga Basin. The Galilee Basin is almost entirely unconformably overlain by the Jurassic-Cretaceous Eromanga Basin. Only along the eastern margin of the Galilee Basin are Permo-Triassic age rocks exposed in a long, narrow and gently curved belt. Maximum known stratigraphic thickness of the Galilee Basin is 2,820 m and the basin is divided into northern and southern parts by the east-west trending Barcaldine Ridge located at approximately 24 degrees south.

Deposition in the Galilee Basin ceased at the end of Triassic, at which time slight erosion and uplift occurred. The Early to Late Jurassic Ronlow Beds of the Eromanga Basin represent a continuation of fluvial deposition. The Ronlow Beds are a marginal facies of the continental sequence of the Eromanga Basin. The Early Cretaceous marked the first period of sea inundation in the region since Early Carboniferous, and formed the Wallumbilla Formation which conformably overlies the Ronlow Beds. Deposition in the Eromanga Basin ceased in the late Cretaceous period.

The stratigraphic succession of the Galilee Basin is partly related to stratigraphic successions in the Cooper and Bowen Basins, with each basin having experienced a hiatus during some part of the Middle Permian period.

In the north of the Galilee Basin, major coal deposition occurred during the Early Permian period in the Joe Joe Group. In the Late Permian period major coal deposition occurred in the Betts Creek Beds, and the regional correlatives in the south of the Galilee Basin, the Colinlea Sandstone and Bandanna Formation. The boundary between the late Permian strata correlatives in the Northern and Southern Galilee Basin is taken at the Barcaldine ridge around 24 degrees south.

Regionally, a thin veneer of more recent Tertiary sediments typically overlies these basins.

Figure 4-9 shows a cross-section of the regional geology in the vicinity of the project site.

4.5.2 Exploration History

Exploration drilling has targeted the Late Permian, coal bearing Betts Creek Beds.

Historical Exploration

The first coal exploration to take place in the Galilee Basin occurred in 1920 near Pentland. In the early 1970s, the then Queensland Mines Department commenced a reconnaissance drilling program along the eastern margin of the Galilee Basin as part of a state-wide coal exploration program. As part of this program, five holes were drilled just to the east of the project site. There was little exploration in the Galilee Basin from the early 1980s until recently.

Recent Exploration

Following the grant of EPC 987 to the proponent in 2006, an exploration drilling program was undertaken from July to October 2008 with twelve core holes drilled. Further exploration was undertaken in 2010 with eighteen core holes drilled.

Between 2011 and 2014 a further 130 open and cored holes and 32 groundwater monitoring bore holes were drilled. This involved a total of approximately 52,000 m of drilling in the southern block of EPC 987, the majority of which was within the project site.

4.5.3 Local Geology

This section describes the stratigraphy, geomorphology and geological structures of the project site and surrounding area.

Stratigraphy

The local stratigraphy is summarised in Table 4-3. The project site is underlain by Galilee Basin and Drummond Basin units. The underlying Drummond Basin comprises Permian and Carboniferous sediments and outcrops approximately 40 km east of the project site. The Eromanga Basin subcrops west of the project site and does not underlie the project site.

Table 4-3 Summary of Local Stratigraphy

SEDIMENTARY BASIN	AGE	FORMATION	PROXIMITY TO PROJECT	REGIONAL CORRELATIONS
-	Quaternary	Quaternary Sediments	Present in surrounding area	-
-	Tertiary	Tertiary Sediments	Present within project site	-
Eromanga	Jurassic	Ronlow Beds	Subcrops west of project site	-
Galilee	Triassic	Moolyamber Formation	Subcrops west of project site	-
		Clematis Sandstone	Present within project site	-
		Rewan Formation	Present within project site	-
	Permian (Late)	Betts Creek Beds	Present within project site	Bandana Formation Colinlea Sandstone
	Permian (Early)	Joe Joe Group	Present within project site	-
Drummond	Permian (Early) / Carboniferous	Basement formations of the Drummond Basin		

In addition to the units presented in Table 4-3, published regional geological information indicates the presence of Warang Sandstone and Dunda Beds in the vicinity of the project site. Clarification with the former Department of Mines and Energy and the Geological Survey of Queensland (pers. comm. Dr J McKellar and Ms S Edwards) confirms that neither is present in the vicinity of the project site; the former being local to the Pentland area of the Galilee Basin, and the latter being present 20 km to the south-east of the project site.

The stratigraphy of the project site is shown on Figure 4-10. Figure 4-11 shows the surface geology of the main stratigraphic units underlying the recent Tertiary Sediments. Quaternary sediments are localised to present day drainage lines.

As shown on Figure 4-10, the stratigraphy of the project site comprises:

- A veneer of highly weathered Tertiary sediments and localised fluvial Quaternary sediments;
- Triassic sediments of the Clematis Sandstone and Rewan Formation; and
- Permian Betts Creek Beds including coal seams and the underlying sediments of the Joe Joe Group.

The stratigraphic units present at the project site and in the surrounding area are described in detail in the following sections.

Quaternary Sediments

Published regional geological mapping indicates the presence of fluvial sediments associated with present day drainage lines (Figure 4-11). The distribution of these sediments in the vicinity of the project site was further investigated through targeted groundwater drilling and stream geomorphology assessments. These assessments are discussed in the *Groundwater Report* (Appendix I) and Section 13 – Surface Water, respectively.

These studies confirmed that the minor drainage lines and overland flowpaths present within the project site and downstream catchment are characterised by rock channels or exposed Tertiary materials. Extensive, deep alluvial deposits and associated shallow groundwater are therefore absent from the project site and surrounding area. Fluvial sediments present in the vicinity of the project site are limited to thin (less than 1 m) patches of mud and gravel.

Tertiary Sediments

The Tertiary sediments comprise claystone and weakly indurated sandstone and siltstone. This unit is a highly weathered, low to moderate permeability detrital deposit that covers much of the low-lying areas either side of the Darkies Range ridgeline. These sediments typically increase in thickness with distance from Darkies Range and within the project site range from zero to 60 m. The Tertiary sediments are thin or absent on the elevated ridge of Darkies Range.

Ronlow Beds

The Ronlow Beds subcrop approximately 26 km west of the project site and do not underlie the project site. These deposits are present to the west of the project site and represent the eastern limit of the Eromanga Basin.

The Ronlow Beds are fluvial deposits of predominantly quartzose sandstone with minor claystone and siltstone. Rowlow Beds are up to 200 m thick. Sandstones are poorly consolidated, off-white to clear and occasionally stained red and orange, with a medium to coarse-grain. They also contain an abundant clay and limonitic matrix. Claystone beds are off white, brown and green with a waxy to fissile texture and locally grade to siltstone.

Triassic Strata

Within the project site and surrounding region, Triassic strata progressively thin eastward as underlying Permian coal seams emerge and subcrop against the Tertiary Sediments. Relevant Triassic strata are described as follows:

Moolayember Formation

The Moolayember Formation is the youngest Triassic formation in the vicinity of the project and comprises mudstone, siltstone and lithic sandstone. This unit subcrops to the west of Darkies Range within 7 km of the project site and dips to the west, reaching thicknesses of over 600 m. The subcropping unit is covered by Tertiary sediments. The Moolayember Formation sits conformably above the Clematis Sandstone.

Clematis Sandstone

The Clematis Sandstone is a massive sandstone unit, with minor interbeds of siltstone and claystone. The sandstone is mostly light grey to off-white with quartzose composition and kaolinitic matrix. Siltstone and claystone are grey and red brown.

This unit outcrops to form the western slopes of Darkies Range where is it is up to 200 m thick along the ridgeline. In this area, the formation is deeply weathered and there are prominent laterite horizons with a red and white appearance and high iron content.

The Clematis Sandstone sits unconformably on Rewan Formation sediments within the project site.

Rewan Formation

The Rewan Formation is a thinly interbedded sequence of siltstone, claystone and minor fine grained sandstone. This unit is predominantly a greenish-grey colour with minor red and brown coloured horizons. It has a low visual porosity.

This unit outcrops along the eastern margin of Darkies Range where the Clematis Sandstone has been removed by erosion. This unit has also been subject to erosion and disconformably overlies the Betts Creek Beds. South of the project site, the upper Rewan Group transitions to the equivalent Dunda Beds. This transition is defined by a progressive increase in sandstone content.

Permian Strata

Betts Creek Beds

The Betts Creek Beds sub-crop under the Tertiary sediments immediately east of Darkies Range and dip gently towards the west. The sub-cropping Betts Creek Beds are deeply weathered and the coal seams are typically absent within this weathered profile. As this unit dips under Darkies Range, the depth increases to between approximately 200 m and 450 m at the western extent of the project site.

The Betts Creek Beds typically consists of light grey, fine to very coarse grained, sublabile to quartzose, sandstone, with interbedded siltstone, mudstone, coal and shale in places. The Betts Creek Beds contains seven major coal seams at the project site. In stratigraphic order from top to base these are the A to G Seams. The overall stratigraphic thickness of the A to G Seam profile ranges from 90 m in the north of the project site to 130 m in the south of the project site, and contains approximately 35 m of coal.

A detailed description of the coal seam and interburden stratigraphy in the Betts Creek Beds is provided in Table 4-4.

Table 4-4 Detailed Summary of Coal Seam Geology Units

UNIT / HORIZON	THICKNESS	DESCRIPTION
A Upper Seam	2.5 - 6.5 m	Plies consist of A Upper 1 (AU1) to AU4. AU1 and AU2 plies join together in the central and northern areas of the project site.
Interburden Unit	Generally < 10 m thick above the A Lower Seam, increasing in the south	Interbedded sandstone and siltstone which thickens considerably in the south trending to coarse grain sandstone.
A Lower Seam	14 m	Mostly dull and stony coal with tuff and claystone partings. Typical density of plies is 1.5 to 1.6 g/cm^3.
Interburden Unit	0 – 50 m	Increases as upper ply splits from the main A/B Seam package. Comprises massive fine to coarse grained sandstone with minor siltstone bands.
B Seam	6 - 7 m	Plies consist of B1 to B3. Package is heavily banded with tuff and claystone. Density ranges from 1.6 to 1.8 g/cm^3. B1 occasionally pinches out and B2 and B3 vary in thickness.
Interburden Unit	15 – 30 m	Interbedded sandstone and siltstone with minor claystone. The immediate floor of B seam is claystone while roof of C Seam (C3 ply) is weak carbonaceous claystone and tuff.
C Seam	0 – 5 m	Six plies. Uppermost C6 in northern section of site and 0.8 m thick emerging from a carbonaceous zone between B1 and C5. C5 ply is tuff banded.
Interburden Unit	10 – 20 m	Contains thin basal plies (C1 and C2) of C Seam, each 1 m or less thick. Unit comprises interbedded sandstone and siltstone becoming predominantly siltstone with sporadic claystone in roof of D Seam. C Seam floor comprises claystone and siltstone.

UNIT / HORIZON	THICKNESS	DESCRIPTION
D Seam	Variable	Three plies. In the north is typically 0-10 m below C1/C2 and remains approximately 10 m below C1 in the south. D2/D1 is 1.8 m thick in the south with a 0.15 m tuff band separating plies. D1 is consistently 1.5 m thick with an average density of 1.4 g/cm^3. D2 remains approximately 0.2 m thick above the tuff parting.
Interburden Unit	5 – 8 m	Comprises interbedded sandstone and siltstone with minor claystone bands. Claystone or siltstone is typical in the immediate roof and floor of D and E Seams.
E Seam	Variable	Two plies. E1 is consistently 1 to 1.2 m thick throughout the site and is separated from E2 by a claystone parting between 0.1 and 0.4 m thick in the central and southern areas. The parting improves to a stony coal band in the northern area uniting the E1/E2 plies into a 1.2 m to 1.5 m seam.
Interburden Unit	5 – 8 m	Comprises fine to coarse grained quartzose sandstone coarsening downwards. E Seam floor usually consists of siltstone, while F Seam roof is medium to coarse sandstone.
F Seam	Variable	Two plies in central area of southern section with approximately 0.6 m parting. Otherwise appears as a 1.4 to 1.8 m seam with an average density of 1.5 g/cm^3. Thickness ranges from 1.2 to 2 m in the northern section.
Interburden Unit	10 – 15 m	Comprises medium to coarse grained sandstone. The F Seam floor and G Seam roof are typically sandstone and on occasion G Seam roof can be conglomeratic. G Seam floor consists of siltstone and claystone.
G Seam	Variable	The G Seam is not laterally consistent across the site and where absent is replaced by coarse sandstone. In the south is approximately 2 m thick with a density range of 1.4 to 1.7 g/cm^3. In the lower north is present in two plies with a thickness of 3 m with 0.8 m parting.

Joe Joe Group

The Joe Joe Group comprises conglomerate, lithic sandstone, siltstone, minor mudstone and coal. The Joe Joe Group is the base unit of the Galilee Basin and underlies the Betts Creek Beds. The Joe Joe Group subcrops in the east of the project site under the Tertiary sediments. There is a localised outcropping of this unit in the south of the project site.

Geomorphology

Darkies Range, a topographic high runs approximately north-south and is present in the western portion of the project site. The range is primarily composed of Triassic Clematis Sandstone which extends beyond the western boundary of the project site (Figure 4-11). Where the Clematis Sandstone has eroded on the eastern slopes of Darkies Range, the underling Rewan Formation is exposed.

The depth to the top of the uppermost A Seam at the project site increases towards the west and Darkies Range, as Triassic strata increases the thickness of overburden.

Palaeontology

Significant fossils are unlikely to be found in the mining area. Permian-age rocks of the Galilee Basin and other contemporaneous basins in eastern Australia routinely contain vegetation fossils and microfauna fossils, however these are not considered to be unique or rare. Although macrofauna fossil assemblages have been identified (rarely) in Permian-age basins in Australia, the nature of the project mining operations are not conducive to unearthing macrofauna fossil assemblages, or any other fossil assemblages. However, should fossils of palaeontological significance be discovered during mining, the immediate site of the fossil find will be isolated and the Queensland Museum notified.

Geological Structures and Features

Within the project site, the coal seams dip gently south-west at about 3º and increase to 6º close to the southern boundary. The current structural interpretation makes use of data from a number of sources, including historic exploration data, targeted exploration drilling within the project site, and data from surrounding exploration programs.

A normal fault has been identified within the Triassic and Permian units in the northern section of the project site, running in a roughly north-south alignment. The down-thrown side of the fault is to the east.

The fault opens and closes at the southern and northern extremities with 100 m maximum displacement in the centre. The fault breaks the continuity of the Clematis Sandstone and on the downthrown eastern side of the fault, places this unit in direct contact with the Rewan Formation that lies on the western side of the fault.

4.5.4 Resource Utilisation

Exploration drilling has identified the A, B, C and D seams as the principal exploration and mining target for the project. While a number of additional seams are present within the project site, drilling to date has indicated that these are not economic to mine.

The assessment of the project’s coal resources and reserves was conducted in accordance with the JORC 2012 Code and was generally in accordance with the principles outlined in the *Australian Guidelines for the Estimation and Classification of Coal Resources* (Coalfields Geology Council of NSW and QLD Resources Council 2014). A summary of the current resource estimate is provided in Table 4-5.

Table 4-5 Coal Resource Summary (Millions of Tonnes)

MINING AREA	MEASURED	INDICATED	INFERRED	TOTAL
MLA 70514	-	-	-	-
MLA 70515	210	440	440	1,090
MLA 70516	620	530	490	1,640
MLA 70517	-	260	1,300	1,560
MLA 70518	-	-	1,300	1,300
Total	**830**	**1,230**	**3,530**	**5,590**

4.5.5 Resource Recovery and Potential for Sterilisation of Resources

The project mining methods and mine designs have been selected and developed to ensure optimum recovery of the target coal resources. The proposed mining operations will not result in the sterilisation of any economic resources. The E, F and G Seams are not proposed to be mined as part of the project. However, these seams have potential for future underground mining subject to further geological exploration, feasibility assessment and approvals.

4.6 MINING

The project will target the A, B, C and D seams in the Permian coal measures. The coal will be extracted using both open cut and underground mining methods. An overview of the two methods is provided in the following sections.

4.6.1 Open Cut Mining

Overview

The A, B and C seams will be targeted in the open cut mine. The C seam will only be mined in the northern end of the open cut. At the southern end of the open cut the C seam will be extracted by the Southern Underground (as discussed in Section 4.6.2). The open cut mine will have a peak ROM production in the order of 32 Mtpa and a mine life in the order of 30 years.

The proposed open cut mine plan and mining schedule are shown on Figures 4-12 to 4-15. Overburden removal in the open cut mine will be via multiple draglines with truck and shovel pre-strip. Coal will be mined using surface miners supported by truck and shovel fleets.

The open cut mining operations will involve the following activities:

- Clearing of any vegetation;
- Stripping and stockpiling of topsoil;
- Drilling and blasting of pre-strip overburden, where necessary;
- Removing the pre-strip overburden using truck and shovel fleets;
- Drilling and blasting of dragline overburden;
- Overburden removal by draglines;
- Coal mining using surface miners and excavators; and
- Progressive rehabilitation of overburden emplacement areas.

A schematic of the open cut mining operations is shown in Figure 4-17.

Coal mined from the open cut pits will be transported to the CHPP ROM coal loading station by haul truck. ROM coal will be crushed and sized after loading and then transported to the raw coal stockpiles or CHPP by overland conveyor. In-pit coal crushing and conveying systems are also being considered as an alternative to minimise haulage of coal by truck.

Open Cut Mine Layout

The open cut mine layout and mining schedule is illustrated in Figures 4-12 to 4-16. Initial boxcuts will be constructed at the eastern extent of the open cut pits, with mining progressing down-dip from east to west. Initial overburden will be stored in out-of-pit overburden emplacement areas to the east of the open cut pits. Once the open cut pits are developed, overburden will be placed in-pit. The overburden emplacements will be rehabilitated progressively over the life of the mine. Rehabilitation is discussed in detail in Section 8 – Rehabilitation.

Four main ramps will provide access from the surface to the pit floor. When fully developed, the open cut pits will be approximately 275 m to 410 m wide and 330 m to 400 m deep, with a total length of approximately 8.7 km.

4.6.2 Longwall Mining

Overview of Longwall Mining

A longwall is a complex system of mining equipment that incorporates hydraulic roof supports (called ‘shields’), coal cutting and coal transport equipment. Longwall mining involves extracting rectangular panels of coal, typically around 150 to 400 m wide, up to 7 km long and 2 to 5 m thick (Figure 4-18). Longwall panels are defined by access roadways that are constructed around the perimeter of each longwall panel. These roadways provide access for the installation of the longwall mining equipment, mine workers and equipment and services.

The longwall mining equipment (coal shearer) travels back and forth across the width of the longwall panel, starting at the furthest point progressively removing the coal from the panel back to the main headings (Figure 4-18). The shearer cuts the coal from the coalface on each pass and delivers the coal to a face conveyor that runs along the full length of the longwall (Figure 4-19). The face conveyor transports the coal from the coalface to another conveyor in an access roadway. Coal is then transported to the surface via a series of connecting underground conveyors.

The roof at the coalface is held up by a series of hydraulic roof supports (Figure 4-19). The supported section of roof provides space for the shearer, face conveyor and man access. After each shear of coal is removed, the face conveyor, hydraulic roof supports and the shearer are moved forward.

The roof immediately above the mined seam collapses into the void (called a ‘goaf’) that is left as the roof supports progressively retreat through the panel. As the roof material collapses into the goaf behind the roof supports, the fracturing and settlement of the rocks progresses through the overlying strata and results in the sagging and bending of the near surface rocks (Figure 4-19). This can result in the progressive formation of gentle trough-like depressions on the surface relative to the natural topography (called subsidence). The subsidence effect moves across the ground at approximately the same speed as the advance of the mining face, which is typically up to 100 m per week. The majority of subsidence at a point on the surface occurs within three months of undermining and all subsidence is generally complete within 12 months. Subsidence is discussed further in the subsidence assessment undertaken for the project (*Subsidence Report*, Appendix A) and Section 6 – Subsidence.

Project Longwall Mining Operations

The project includes up to three longwalls operating in two underground mining areas, the Southern Underground and Northern Underground (Figure 4-2). The Southern Underground will extract the C seam below the southern end of the open cut mine (Figure 4-20). Mining in areas of the Southern Underground will be completed prior to any open cut mining in the area above (Figures 4-12 to 4-15). The Southern Underground will have a peak ROM production of up to 8 Mtpa and a mine life in the order of 13 years.

The Northern Underground will involve two longwalls extracting the D seam and A seam in the northern section of the project site (Figures 4-21 and 4-22). The Northern Underground will have a peak production of up to 15 Mtpa and a mine life in the order of 47 years.

Longwall Layouts

The conceptual longwall layouts are described in the following sections. Modifications to the underground mine layouts may be necessary based on the results of future geological exploration and more detailed mine planning. However, any revised longwall layouts would not have any significant additional impacts beyond those presented in this EIS.

Southern Underground

The C seam longwall panels will be approximately 300 m wide and vary in length from approximately 0.5 km to 4.2 km. The longwall panels will have an extraction height of approximately 4.5 m. The width of the proposed chain pillars (the coal left between the longwall panels) will be approximately 35 m. In the longwall mining area, the depth of the C seam ranges from approximately <100 m to 450 m.

Northern Underground

The D seam longwall panels will be approximately 300 m wide and vary in length from approximately 0.8 km to 3 km. The longwall panels will have an extraction height of between 3.0 and 4.5 m. The width of the proposed chain pillars (the coal left between the longwall panels) will be approximately 35 m. In the longwall mining area, the depth of the D seam ranges from approximately 200 m to 490 m.

The A seam longwall mine is located above the D seam longwall mine. The A seam longwall panels will be approximately 300 m wide and vary in length from approximately 1 km to 4.8 km. The longwall panels will have an extraction height of approximately 4.5 m. The width of the proposed chain pillars (the coal left between the longwall panels) will be approximately 35 m. In the longwall mining area, the depth of the A seam ranges from approximately 140 m to 420 m.

Mine Access Roadways

Mine access roadways will be developed to provide access to the longwalls for mine workers, ventilation and equipment. These roadways will be developed within the coal seam and are typically 5.5 m wide and 4 m high. The roadways will be constructed using continuous miners (electric mining machines that excavate the roadways) and shuttle cars (electric mining machines that transport excavated material to the underground conveyor system).

Underground Mine Entries

Access to the Southern and Northern underground mining areas will be provided via inclined drifts (i.e. tunnels) from the surface to the underground workings.

Each mining area will have separate drifts for men and materials access, and the ROM coal conveyor to the surface. The drift portals will be located near the respective underground mine industrial areas. The locations of the drifts and portals for the Southern and Northern Undergrounds are shown in Figures 4-20 and 4-21, respectively.

Underground Mining Schedules

The mining schedules for the three longwalls have been developed in order to manage potential interactions between the various mining operations. The C seam longwall in the Southern Underground has a mine life in the order of 13 years and is expected to be completed by Project Year 15. The Southern Underground is located within the footprint of the southern section of the open cut mine. The mining schedules have been developed such that C seam longwall extraction in areas of the Southern Underground will be completed prior to any open cut mining in the area above.

The A and D seam longwalls are both located in the Northern Underground within the northern section of the project site. Longwall extraction in the D Seam and A seam commences in Project Year 3. The mining schedules for the D seam and A seam longwalls have been developed to ensure there is a minimum 5 year lag between extraction of the D seam, and extraction of the A seam. This will ensure that all subsidence from extraction in the D seam has completed prior to extraction of the overlying A seam.

4.7 ONGOING EXPLORATION ACTIVITIES

An ongoing exploration program will be undertaken over the life of the mine. This may include installation of exploration boreholes, as well as 2D seismic surveys in some areas. These activities are similar to the exploration activities that have been undertaken on the project site to date. There is considerable flexibility with respect to the location of exploration bores and, as per current practice, exploration bores will be sited to avoid significant surface features, as far as possible. Similarly, there is flexibility in the layout of any 2D seismic exploration programs. These will be designed to minimise any disturbance of vegetation.

4.8 MINE INFRASTRUCTURE

The majority of mine infrastructure will be located to the east of the open cut mining area (Figure 4-23). Key infrastructure in this area will include:

- Haul roads and access roads;
- Raw and product coal stockpiles and coal conveyors;
- CHPP and associated coal handling facilities;
- Rail loop and train loading facility;
- Power Station;
- Workshops and vehicle servicing facilities;
- Warehouses, laydown and storage areas;
- Administration buildings and employee facilities;
- Workforce accommodation village;
- Private airstrip;
- Mine waste storage facilities; and
- Numerous sediment control and water storage dams.

Key mine infrastructure components are discussed in the following sections.

4.8.1 Open Cut Mine Infrastructure

An Open Cut Mine Industrial Area (MIA) will be located to the east of the out-of-pit overburden emplacement areas (Figure 4-24). The Open Cut MIA will include buildings specifically associated with the open cut mining operations, including a radio control centre, offices and employee facilities.

Other open cut mining infrastructure will be located within the open cut mine footprint, and to the east of the out-of-pit overburden emplacement areas including:

- Haul roads and ramps providing access to the open cut pits;
- ROM coal dump hoppers at the CHPP loading station;
- Coal stockpiles;
- Laydown areas; and
- Ammonium nitrate storage.

The location of open cut mining infrastructure is shown on Figure 4-24.

4.8.2 Underground Mine Infrastructure

Infrastructure associated with the underground mines will be located close to the drift portals for each underground mining area. The Northern Underground MIA, which will service the A and D seam longwall mines, will be located near the north-eastern corner of the open cut mining area (Figures 4-23 and 4-25).

The Southern Underground MIA, which will service the C seam longwall, will be located near the product coal stockpiles towards the southern end of the open cut mining area (Figures 4-23 and 4-26).

Infrastructure in the underground MIA's will include:

- Administration buildings, bathhouse and employee facilities;
- Workshop, servicing and refuelling facilities;
- Warehouse, storage and laydown areas;
- Security, first aid, mine rescue and fire services facilities;
- Water storage dams;
- Water and sewage treatment plants; and
- Car parks.

A number of minor surface facilities will be required above the longwall mining areas. These will include ventilation shafts, underground communication cables, mine dewatering boreholes and associated pipelines, and other access boreholes. These facilities will have a relatively small footprint. Ventilation shafts have the largest footprint at approximately 15 m x 15 m per shaft. There is flexibility in the siting of these facilities and they will be sited, where practicable, to avoid disturbance of any significant surface features, such as drainage lines or vegetation within threatened species habitat. Given the flexibility in the location of this minor infrastructure it is expected that this infrastructure will generally be able to be located to avoid any significant environmental impacts. A formal process will be established for the selection of locations for this minor infrastructure.

4.8.3 Coal Handling and Transport Infrastructure

The coal handling and coal transport system within the project site will include the following components:

- Open cut coal handling and transport:
    - Truck haulage of ROM coal from the open cut pits and/or field ROM stockpiles to dump hoppers at the CHPP loading station.
- Underground coal handling and transport:
    - Underground conveyor systems for transporting coal from the underground workings to surface ROM coal stockpiles adjacent to each underground MIA;
    - Overland conveyor transporting coal reclaimed from the Northern Underground ROM coal stockpile to the CHPP loading station; and
    - Truck haulage of ROM coal from the Southern Underground ROM coal stockpile to the CHPP loading station.
- ROM coal crushing, screening and sizing at the CHPP loading station;
- Conveyor system transporting raw coal from the CHPP loading station to the raw coal stockpiles;
- Raw coal stockpile reclaim and conveying to the CHPP for washing;
- Conveyor system transporting washed product coal from the CHPP to the product coal stockpiles;
- Product coal stockpile reclaim and conveying to the train loadout; and
- Loading of trains for transport of product coal by rail to port.

The location of the various components of the coal handling and transport system is shown in Figure 4-24 and a conceptual process flow sheet is shown in Figure 4-27.

4.8.4 Drainage and Flood Protection Infrastructure

A network of drainage and flood protection infrastructure is proposed to be constructed on the project site, progressively over the life of the mine. This infrastructure will ensure effective drainage of the site, minimise the generation of mine-affected water and provide an appropriate level of flood protection for the mining operations and mine infrastructure. This infrastructure will include a network of diversion drains and catch drains. Surface drainage is addressed in detail in Section 13 – Surface Water.

4.8.5 Utilities

Table 4-6 summarises the utilities required for the project.

Table 4-6 Utilities

UTILITY	AVERAGE DEMAND	SOURCE
Energy		
Electricity	1,320 GWH/year	Electricity requirements for initial construction will be supplied by 14 MW diesel generators. Power for the remainder of the project life will be provided by the on-site power station.
Diesel	90,000 kL/year	Diesel will be supplied by a contracted service provider. Diesel storage is discussed in Section 22 – Hazard and Risk and the on-site fuel storage area is shown on Figure 4-24.
Water		
External Raw Water	12,500 ML/year (maximum)	The external water supply is discussed in Section 4.13.4. The proposed reuse of mine-affected water for mine water supply is discussed in Section 13 – Surface Water. On-site package water treatment plants will be installed at the mine industrial areas and at the accommodation village in accordance with relevant standards and regulatory requirements.
Other		
Sewerage	Up to 1,000 kL/day	Package sewage treatment plants with a total capacity of approximately 440 kL/day will be constructed within the mine industrial areas. The accommodation village sewage treatment plant will have a peak capacity of approximately 560 kL/day. Sewage treatment plants will be constructed and operated in accordance with relevant standards and regulatory requirements.
Telecommunications	Telephone, internet, facsimile and security alarms	Necessary telecommunications infrastructure will be installed by a suitably qualified service provider.

4.9 REJECTS AND TAILINGS STORAGE

4.9.1 Coarse Rejects

Coarse rejects generated from the CHPP will be stockpiled at the rejects stockpile adjacent to the CHPP (Figure 4-24). Rejects will be loaded to trucks and hauled to the overburden emplacement area for disposal within the active overburden emplacement areas. Coarse rejects may also be used during the construction of the TSF, subject to the results of geotechnical testing to confirm the suitability of the material. The geochemical characterisation of the rejects material and rehabilitation of the overburden emplacements is discussed in Section 8 – Rehabilitation.

4.9.2 Fine Rejects

Fine rejects, referred to as tailings, will be generated by the coal washing process at the CHPP. Tailings will be transported via a slurry pipeline to a designated TSF (Figure 4-23). The TSF will be a conventional tailings dam with sufficient capacity for life-of-mine tailings storage.

The TSF will have nil external catchment and will be operated to ensure that it does not overflow. A decant pond with a pontoon mounted pump will be maintained within the active tailings storage area. Tailings water and rainfall runoff will collect in the decant pond and will be returned to the CHPP for water supply. Water management associated with the TSF is discussed in more detail in Section 13 – Surface Water.

The TSF will have a capacity of approximately 100 Mm^3 with an ultimate footprint of approximately 600 ha and a maximum embankment height of 34 m. The geochemical characterisation of tailings and the design, operation and rehabilitation of the TSF are discussed in detail in Section 7 – Tailings and Power Station Waste Storage Facilities.

4.10 POWER STATION

A coal fired power station is proposed to be constructed in stages on the project site. The power station will be used to power the mine. The power station will be air-cooled and utilise circulating fluidized bed technology. Fine rejects from the CHPP, supplemented with raw coal, will be used to fuel the power station.

The power station will comprise 350 MW supercritical generating units. 350 MW generating units are proposed in order to maximise thermal efficiency, consistent with best practice.

Two generating units will need to be operational to supply the potential maximum peak mine power demand. Peak demand will include the operation of:

- Open cut mine at peak production with two separate pits and including two large scale draglines;
- Three longwalls;
- 55 Mtpa capacity CHPP; and
- Other associated facilities such as workshops, workforce accommodation village and supporting infrastructure.

A third generating unit will be provided as redundancy. Due to the remote location of the project site, the power station is required to have redundancy to ensure a reliable power supply for mining operations.

At full generating capacity, the power station would have sufficient spare capacity for maintenance and potential future supply to off-lease users. Any future off-lease supply of power would be subject to separate approvals.

The layout of the power station is shown in Figure 4-28 and consists of the following key components:

- Feed coal stockpiles and conveyors;
- Generating (boiler) units and transformers;
- Warehouse and storage areas; and
- Administration and control buildings.

4.10.1 Power Station Waste Storage Facility

The power station will generate dry waste material in the form of fly ash, bottom ash and clinker. These dry waste materials will be transported by haul truck for storage in a designated Power Station Waste Storage Facility (PSWSF), located to the north-east of the power station (Figure 4-24). The PWSF will have sufficient capacity to store the power station waste for the first 10 years of operation. After this time, the power station waste will be stored within the overburden emplacement areas.

The dry power station waste will be placed in the PSWSF using dump trucks in a similar manner to the development of an out-of-pit overburden emplacement. The material will be paddock dumped and spread with a dozer in successive lifts.

The PSWSF will have a capacity of approximately 16.4 Mm^3 with an ultimate footprint of approximately 80 ha and a maximum height of 30 m. The geochemical characterisation of power station waste material and the design, operation and rehabilitation of the PSWSF are discussed in detail in Section 7 – Tailings and Power Station Waste Storage Facilities.

4.11 ACCOMMODATION VILLAGE

An accommodation village will be constructed in the south-eastern part of the project site to accommodate the project workforce (Figure 4-29). The accommodation village will be located adjacent to the airstrip to facilitate the efficient movement of workers to and from the site.

An initial stage of the accommodation village will be completed as a priority during Project Year 1 to house the construction workforce. This section will comprise approximately 560 rooms and will operate on a motelling basis. The operations stages of the accommodation village will be constructed progressively as the workforce increases. The ultimate village will comprise approximately 3,050 rooms.

The accommodation village is intended to be self-sufficient with regard to communications infrastructure, recreational facilities and medical services. The accommodation village will include:

- Tennis court, gym, swimming pool, shops and recreation facilities;
- Administration buildings, bathhouse and employee facilities;
- Kitchens and mess halls;
- Health and first aid facilities; and
- Water and sewage treatment facilities.

Further details on accommodation village and its facilities are provided in the *Socio-Economic Impact Assessment Report* (Appendix N).

4.12 PRIVATE AIRSTRIP

A private airstrip will be constructed in the south-eastern part of the project site, for the transport of mine workforce and materials (Figure 4-29). Construction of the airstrip is scheduled to be completed prior to the end of Project Year 1, for the transport of the project workforce from Project Year 2 onwards. The airstrip facilities will include baggage handling and passenger security.

The airstrip will be designed to cater for a range of aircraft, including Boeing 737s, Airbus 320s and Bombardiers. Current planning estimates approximately 40 flights per week will be required during operations, from a range of coastal centres.

The airstrip will be designed, constructed and operated in accordance with the Civil Aviation Safety Authority regulations and guidelines.

4.13 OFF-LEASE INFRASTRUCTURE

The scope of the EIS is limited to the mine site activities and does not include off-lease infrastructure that will be required for the project. Off-lease infrastructure will include port capacity, rail connection to port, mine site access road connection and raw water supply. These will subject to separate environmental impact assessments and approvals. The current preferred option and status of each off-lease infrastructure component are discussed in the following sections.

4.13.1 Port Capacity

The proponent is proposing to obtain access to export capacity at the Abbot Point Coal Terminal via a port access agreement with a third party. The proponent will not be directly involved in any port development for the purposes of the project. Any development of export capacity at the Abbot Point Coal Terminal necessary for the project will be developed by others and would be subject to separate approvals to be obtained by others.

4.13.2 Rail Connection to Port

The project includes an on-site rail loop and train loading facility (Figure 4-24). The on-site rail will connect to a future off-site rail spur connecting the mine site to a future rail line from the Galilee Basin to the Abbot Point Coal Terminal. The rail line connecting the Galilee Basin to the Abbot Point Coal Terminal will be developed by another party. The proponent will be responsible for developing the off-site rail spur connection. However, the alignment of the preferred rail line from the Galilee Basin to the Abbot Point Coal Terminal is not certain at this stage and consequently it is not possible to confirm the location of the off-site rail spur connection. The off-site rail spur would be subject to a separate environmental impact assessment and approvals. These will be progressed once the alignment of the rail spur can be determined.

4.13.3 Mine Site Access Road Connection

Access to the project site will be via a new mine access road to be constructed from Moray-Carmichael Road. However, Adani Mining Pty Ltd (Adani) is proposing to realign a section of Moray-Carmichael Road as part of the development of the adjacent Carmichael Coal Mine and Rail Project (CCM&RP). Adani’s proposed realignment of the road has not yet been confirmed or approved and consequently the precise location of the mine access road for Project China Stone cannot be confirmed at this stage. In addition, responsibility for constructing the mine access road has not yet been confirmed. The mine site access road would be subject to a separate environmental impact assessment and approvals. These will be progressed once the alignment of the access road connection can be determined.

A new intersection with Moray-Carmichael Road will be required for the mine site access road. The location and design of this intersection will be determined in consultation with the Isaac Regional Council who own the road.

The intersection will be designed and constructed in accordance with appropriate engineering standards and the Isaac Regional Council's requirements.

Project traffic impacts are discussed in detail in Section 19 – Traffic and Transport.

4.13.4 Raw Water Supply

The project will require an external raw water supply of up to approximately 12,500 MLpa. There are a number of parties currently developing water supply options for the Galilee Basin coal mines. The current preferred water supply option would be to gain an allocation from a piped water supply from one of two schemes being proposed to harvest water from the Cape River or the Belyando/Suttor River system. The latter scheme has the potential to be supplemented by a connection to the Burdekin Falls Dam. Any future water supply development would be developed by others and would be subject to separate environmental impact assessment and approvals.

These off-lease project components are not discussed further in this EIS.

4.13.5 Potential Interactions with Other Northern Galilee Basin Developments

Other proposed developments in the Northern Galilee Basin include the CCM&RP and the associated Moray Power Project (MPP). These projects are further advanced in the approval phase and are likely to be developed in advance of Project China Stone.

As discussed in Section 4.13.2, the current preferred option for a rail connection from the project site to the port is dependent on the development of a rail connection from the Galilee Basin to Abbot Point by others. The CCM&RP is the current preferred option for this rail connection.

As discussed in Section 4.13.3, the CCM&RP involves the realignment of a section of Moray-Carmichael Road. Access to the Project China Stone site will also be from Moray-Carmichael Road. Based on current scheduling, any realignment of the road as part of the CCM&RP will be completed prior to the commencement of Project China Stone construction.

The CCM&RP involves the development of an accommodation village and airstrip for the accommodation and transport of mine workers. The option of a shared accommodation village and airstrip with the CCM&RP was considered. At present, the CCM&RP's proposed accommodation village is approximately 30 km from the project site. The option of an on-site accommodation village and airstrip is considered the most feasible for the project workforce, however the proponent will continue discussions with Adani regarding the possibility of shared accommodation and airstrip facilities.

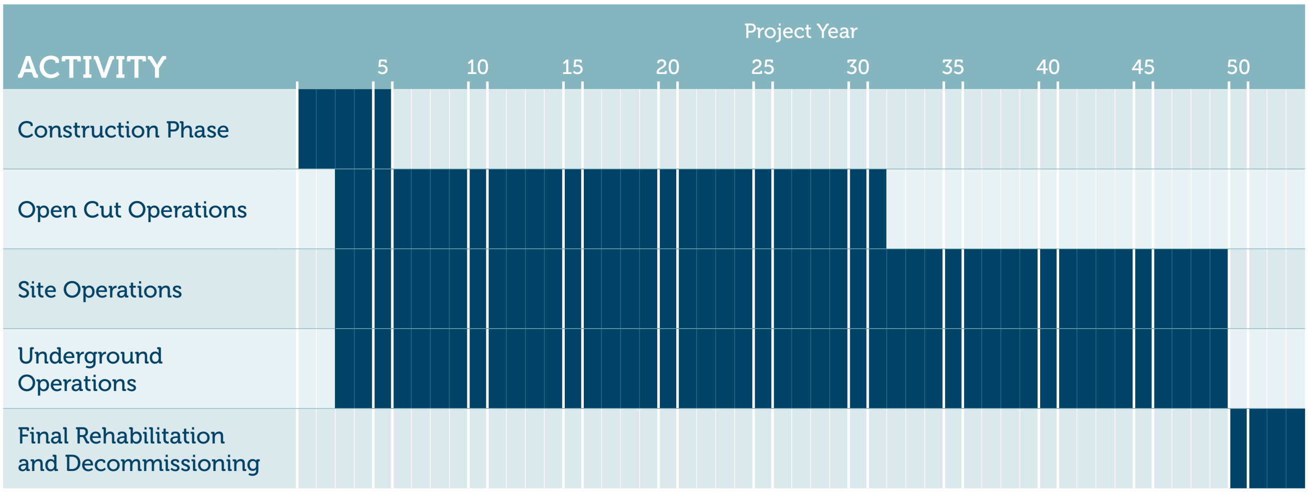
The MPP involves the construction and operation of a new 150 MW thermal and diesel power station to supply power to the CCM&RP. The MPP site is adjacent to the proposed Carmichael Coal Mine site. It is noted that the MPP approval application indicates that the MPP could be expanded in the future, subject to additional approvals, to supply other users including other Galilee Basin coal mines. As discussed in Section 4.16.1, the low cost power supply provided by Project China Stone's on-site power station is fundamental to the economic feasibility of the project and other options for project power supply are not being considered at this stage.

4.14 CONSTRUCTION AND DEVELOPMENT

4.14.1 Project Development Schedule

The following chart provides the key milestones in the proposed project development schedule. It is important to note that this is an indicative schedule, subject to change based on detailed planning and mining conditions. The timing of the commencement of construction is also subject to the receipt of environmental approvals, a mining lease and other necessary approvals. Project Year 1 is currently anticipated to be 2016, subject to gaining the necessary approvals.

Chart 4-1 Project Development Schedule



Construction of mine site infrastructure, including the accommodation village and air strip is scheduled to commence in Project Year 1. Construction of mine infrastructure is scheduled to be completed in Project Year 5. First coal production from the open cut and underground mines is scheduled for Project Year 3, once initial mine development works have been completed. Open cut mining is expected to be completed by Project Year 32 and underground mining would continue until Project Year 49. Mining will be followed by a final rehabilitation and decommissioning period.

4.14.2 Project Development Activities

The main construction and development activities associated with the development of the project are as follows:

- Construction of the accommodation village and airstrip;
- Construction of mine infrastructure and the coal handling and transport system;
- Construction of the power station;
- Open cut mine development;
- Underground mine development; and
- Final Rehabilitation and decommissioning.

These activities are discussed in the following sections.

Accommodation Village and Airstrip

The staged construction of the accommodation village is scheduled to commence in Project Year 1 and be completed by Project Year 2. The initial stage of the accommodation village for the construction workforce will be constructed from the commencement of the construction phase. This initial stage will accommodate up to 1,120 construction workers. It will be constructed over 5 months in Project Year 1. This stage will include 560 prefabricated Single Person Quarters (SPQs). The initial construction village will include a full kitchen and associated facilities, offices, first aid and emergency services facilities and will remain in use as supplementary accommodation after the operations village stages are completed.

The first stage of the operations village will involve construction of 1,280 SPQs over 9 months in Project Year 1. The final stage of the operations village will involve construction of the remaining 1,768 SPQs over 11 months in Project Year 2. The final stage will also involve completion of the kitchen(s), mess hall, offices, shops, village square, recreational facilities, swimming pool, gyms, multifunction hall, recreation pavilion(s), laundries and communal facilities.

Due to the remote location of the project site the large majority of the construction and operations workforces will work on a fly-in/fly-out basis. The private airstrip will therefore be constructed at the commencement of the construction phase and is expected completed and commissioned by the end of Project Year 1.

Mine Infrastructure

Construction of mine infrastructure and the coal handling and transport system will involve:

- Clearing vegetation, topsoil stripping, site preparation and drainage earthworks. Earthmoving equipment such as dozers, scrapers, excavators, trucks, graders, water carts and compactors would be used.
- Construction of roads and on-site rail including culverts and drains using conventional road and rail construction plant.
- Building construction for the administration buildings, workshops, warehouses and small buildings.
- Installation of site services including power, water distribution, water treatment, sewage treatment and telecommunications.
- Erection of steel structures associated with the CHPP and coal handling system. Steel structures would be constructed using standard construction techniques involving equipment such as cranes, scissor lifts and concrete pumps.
- Construction of water supply dams, mine water dams, initial TSF embankment and PSWSF area. Construction of the TSF and PSWSF is discussed in detail Section 7 – Tailings and Power Station Waste Storage Facilities. Mine water dams are discussed in Section 13 – Surface Water.

Construction of mine infrastructure, including the CHPP and coal transport system, will commence in Project Year 1 and will be completed progressively over a period of five years. The CHPP will be built in modules with the commissioning of the initial modules completed in Project Year 3 to coincide with scheduled first coal production. Commissioning of the final CHPP unit is scheduled in Project Year 5.

Construction of the on-site rail loop and train loadout is scheduled to commence in Project Year 2, with the target date for first coal railed in Project Year 3.

Over dimensional loads associated with the delivery of equipment to the project site during the construction phase are discussed in Section 19 – Traffic and Transport.

Power Station

The staged construction of the power station is scheduled to commence in Project Year 1 and will be completed in Project Year 5.

The power station will consist of 3 x 350 MW boiler units, which will be constructed in stages. Power station earthworks and site preparation will commence in Project Year 1, together with construction of the power station infrastructure. Each 350 MW boiler unit will be commissioned sequentially, with the first boiler unit commissioned in Project Year 3. The remaining two units will be commissioned by Project Year 5.

Initial power requirements for the project will be provided by 14 MW diesel generators. Once the power station is constructed the diesel generators will be decommissioned.

Open Cut Mine Preparation Works and Development

The open cut mine preparation and development works will involve:

- Clearing vegetation, topsoil stripping and drainage earthworks. Heavy earthmoving equipment such as dozers, scrapers, excavators, trucks, graders, water carts and compactors will be used.

- Initial box cut overburden removal using heavy mining earthmoving equipment such as dozers, excavators, trucks, graders and water carts. Boxcut overburden will be stored in the out-of-pit overburden emplacement. Some overburden material may also be used as construction material, where suitable.
- Establishment of haul roads and box cut pit ramps using mine haul road construction plant.
- Construction of the initial open cut mine drainage system, pit water dams and associated pump and pipeline systems.

Construction of the initial box cut pits is scheduled to commence in Project Year 1 with open cut coal production in Project Year 3.

Underground Mine Development and Commissioning

The underground mine development works will involve:

- Construction of the mine access drifts using a road-header, which is a track-mounted machine designed to cut stone. Drift spoil will be stored in the open cut mine overburden emplacement or used as construction material, if suitable.
- Underground development involving construction of the initial underground in-seam access roadways with continuous miners. Underground development will also involve construction of associated facilities including ventilation, conveyors and other underground mine services.
- Installation and commissioning of the longwalls in the initial panels.

Underground mine development is scheduled to commence in Project Year 1 with the commencement of construction of the drifts. First longwall coal production is scheduled for Project Year 3.

Final Rehabilitation and Decommissioning

Mining would be followed by a decommissioning and rehabilitation period lasting up to four years in which infrastructure such as buildings, conveyors and dams will be decommissioned and dismantled and final rehabilitation will be undertaken and monitored. Decommissioning of the site is discussed in Section 8 – Rehabilitation.

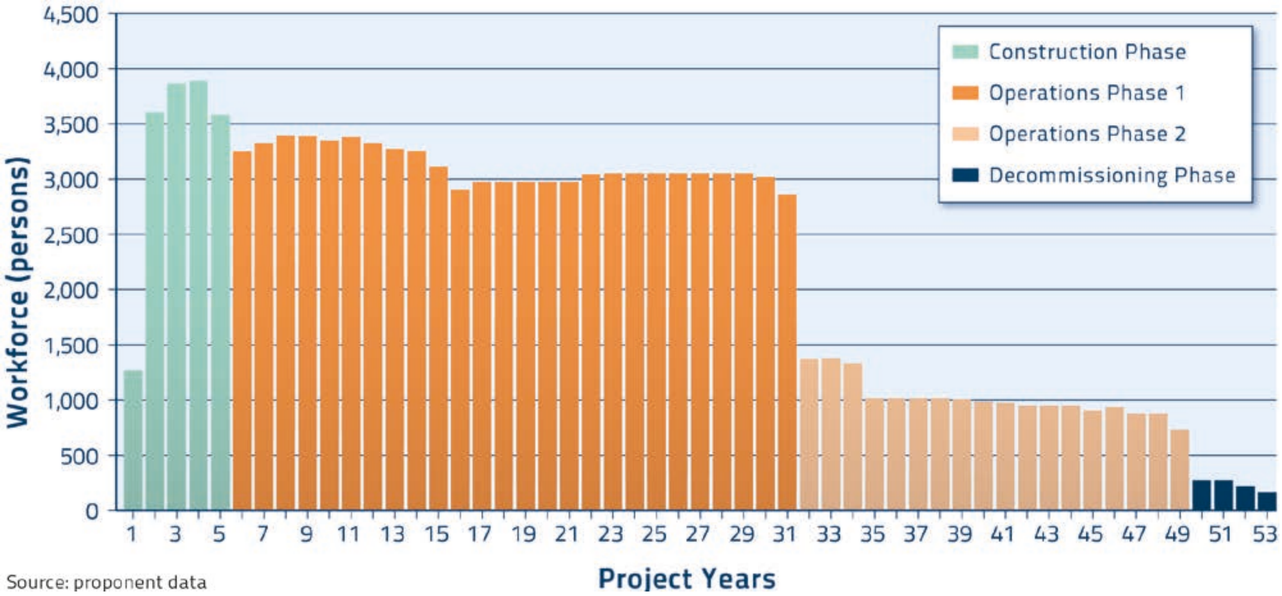
4.14.3 Operating Hours

Construction and operations will be undertaken 24 hours/day, 7 days/week.

4.15 WORKFORCE

The workforce is described in detail in Section 18 – Socio-Economic Impact Assessment and the *Socio-Economic Impact Assessment Report* (Appendix N). The workforce figures presented in these sections and summarised below are based on current planning and are subject to change as more detailed planning is undertaken.

The following graph illustrates the anticipated project workforce by project phase.



Source: proponent data

4.15.1 Construction Phase Workforce

The construction phase for the project extends from Project Year 1 to Project Year 5 and involves:

- The construction of mine site infrastructure and buildings;
- The early development operations for the open cut pit;
- The early development operations for the underground longwalls; and
- The operation of site facilities.

During the construction phase, the size of the workforce will rise and fall to adjust to the requirements of the project. The anticipated peak workforce during the construction phase of 3,892 persons is associated with the fourth year of construction (Project Year 4). It is anticipated that the majority of the workforce during the construction phase will be employed as contractors.

4.15.2 Operations Phase Workforce

There are two distinct operations phases for the project. Operations phase 1 includes the operation of the open cut mine, as well as operation of the three underground longwall mines. Operations phase 1 represents the peak operations phase for the project and runs from Project Year 6 to Project Year 31. Operations phase 1 will have an average annual workforce of 3,119 persons across the phase and a peak workforce of 3,391 persons in Project Year 8.

Operations phase 2 runs from Project Year 32 to Project Year 49 and commences following the completion of open cut mining. Mining in operations phase 2 are limited to the A and D seam longwall mines in the Northern Underground. This phase has an average annual workforce of 1,016 persons. The peak workforce in this phase is 1,377 persons in Project Years 32-33.

At the completion of mining in Project Year 49, a four-year decommissioning phase will run from Project Year 50 to Project Year 53. A small decommissioning workforce is expected to be required for this phase, with a peak of 275 workers in Project Year 50.

4.16 PROJECT ALTERNATIVES AND JUSTIFICATION

4.16.1 Project Alternatives

The key aspects of the project where alternatives were considered during project planning include:

- Alternative resources;
- Alternative mining methods;
- Alternative project layout;
- Alternative tailings storage strategies;
- Alternative power supply options;
- Alternative workforce strategy; and
- Alternative open cut ROM coal transport options.

Alternative Resources

The project involves mining the A, B, C and D seams. Investigations to date indicate that these are the only economically viable coal seams within the project site. Mining of the remaining seams within the project site is not economically feasible (Section 4.5).

Alternative Mining Methods

The project involves mining the shallower coal seams by open cut mining, and the deeper coal seams by underground mining. The coal seams in the open cut mining area are thick and could not be extracted by underground mining methods with an acceptable level of resource recovery or economic viability. Open cut mining is not economically viable for the deeper underground seams.

The proponent intends using conventional longwall mining methods for extraction of the deeper target seams. Alternative underground mining methods including Longwall Top Coal Caving and bord and pillar mining were considered. Longwall Top Coal Caving was considered in the A seam underground mine, however it is not proposed due to the uncertainty and associated risk in relation to its technical feasibility.

Bord and pillar mining would result in reduced surface subsidence effects in the underground mining areas. However, the method would also result in lower resource recovery and is not feasible for a high production capacity mining operation.

Alternative Project Layout

Alternative project layouts were considered during the project planning phase. However, the opportunities for alternative layouts are constrained by the location of the coal resources and the area available for the construction of infrastructure on the project site. The location of the open cut mine is determined by the shallower target coal seams. The location of the underground mining areas are determined by the location of the target coal seams, and are designed to maximise resource utilisation. The proponent does not own any land beyond the boundary of the proposed ML and therefore does not have an option to locate any of the mine site infrastructure beyond the ML. The eastern portion of the project site is the only suitable and sufficient area available for the construction of the mine infrastructure.

In order to enable management of drainage through the project site and to minimise the impact of the project on downstream drainage, the design of the mine infrastructure area includes drainage corridors at the northern and southern ends with capacity to convey drainage through the site (Figure 4-30). The northern corridor has been designed to avoid disturbance of a drainage line traversing the north-eastern corner of the site. The establishment of these drainage corridors also avoids disturbance of the remnant vegetation and fauna habitat in these areas, as shown in Figure 4-30.

The entire project site is well vegetated with remnant vegetation and hence there is no potential alternative project layout that would avoid clearing of remnant vegetation. High value habitat areas for threatened species listed under the Queensland *Nature Conservation Act 1992* and the Commonwealth EPBC Act are located in the proposed open cut mining and mine infrastructure areas (Figure 4-30). Avoidance of any additional areas of habitat in this area is not possible without sterilising open cut mine reserves and/or eliminating mine infrastructure from the project site and hence making the project unviable. Biodiversity offsets are proposed to offset these unavoidable impacts.

Vegetation and fauna habitat within the northern section of the project site will be largely unaffected by the project. Disturbance in this area will be limited to relatively minor impacts due to the rehabilitation of subsidence effects. Appropriate management and monitoring is proposed for these minor impacts.

The proposed project layout has been developed taking into account these constraints.

Alternative Tailings Storage Strategies

Alternative tailings disposal strategies were considered as part of project planning. Alternative options considered included storage within the open cut pits and disposal of dewatered tailings within the overburden emplacement.

The option for in-pit storage was not progressed for the purposes of the EIS as it is not feasible in the initial years of operations due to a lack of available in-pit storage area. The potential feasibility of this option in later years would be subject to very detailed production scheduling, open cut mine planning and open cut mine scheduling, as well as detailed geotechnical investigations. This option may be considered again in the future, subject to the completion of favourable feasibility studies and gaining the necessary approvals.

Disposal of dewatered tailings in the overburden emplacement was considered, however due to the volume of tailings being generated by the project, mechanical dewatering of the tailings is not considered economically viable.

A conventional tailings dam is proposed as it is a proven and economically viable option considering the volume of tailings generated by the project.

Alternative Power Supply Options

Alternative power supply options, including the construction of a high voltage transmission line to connect to the existing power grid, were considered as part of project planning. This option was not preferred due to the higher operating and power purchase costs, long lead time for a connection, and potential transmission loss due to the long distances involved. In particular, the costs associated with importing power over the proposed 50 year mine life are considerable and variable and outweigh the capital expenditure to construct an on-site power station. This is due to the low on-site power production costs, predominantly due to the power station being fuelled by washery rejects and coal extracted as part of mining activities.

It is noted that there is a current Development Application, lodged in November 2014, for a 150 MW power station to be developed by Moray Power to supply the Carmichael Coal Mine. MacMines is not considering a future expansion of this power station as a potential alternative power supply source as the low cost power supply provided by MacMines' on-site power station is fundamental to the economic feasibility of Project China Stone.

The construction of an on-site power station fuelled by coal reject material is the preferred option for mine power supply as it provides the most cost effective power supply for the project. The use of washery rejects in the feed to the on-site power station will ensure the lowest cost fuel supply of any thermal power station in Queensland. The on-site power station also results in higher resource utilisation, greater security for power supply, and the potential option of future supply to off-lease parties.

Alternative Workforce Strategy

Alternatives workforce strategies were considered as part of project planning. Alternatives included:

- The option for workers to live locally;
- Construction of an off-lease township; and
- A shared accommodation village or township with Adani.

Due to the remote location of the project site, there are limited options for workers to live locally. The nearest townships to the project site are Charters Towers, located approximately 285 km by road to the north, and Clermont, located approximately 260 km by road to the south-east (Figure 4-1). While a small portion of the workforce is expected to be sourced from the existing populations of these towns, it is considered unlikely that workers would move to these locations to take up employment on the project. Driving time from these locations would be greater than the flight time from coastal home-base locations.

Construction of an off-lease township was considered as part of project planning, however due to the remote location of the project site and the lack of surrounding amenities or infrastructure, it is considered unlikely that the project workforce would move their families to be near the project site.

The option of a shared accommodation village or township with Adani was considered. At present, Adani’s proposed accommodation village is approximately 30 km from the project site. The option of an on-site accommodation village is considered the most convenient for the project workforce, however the proponent will continue discussions with Adani regarding the possibility of a shared facility.

Alternative Open Cut ROM Coal Transport Options

In-pit coal crushing and transport of raw coal from the open cut pits to the CHPP raw coal stockpiles by conveyor is an alternative to transporting coal from the pits in haul trucks. The EIS studies have been based on haulage of open cut coal by truck as this would be the worst case with regard to potential environmental impacts. For example, the noise and dust emissions from coal haul trucks would be higher than a coal conveyor. A final decision on the preferred transport option for open cut coal will be made during detailed open cut mine planning.

4.16.2 Project Justification

The proponent’s justification for the project is:

- It involves a responsible mine plan that incorporates appropriate constraints and control measures to limit any adverse environmental and social impacts to an acceptable level;
- It maximises the responsible utilisation of the coal resource; and
- It will result in significant economic benefits for the local area and Queensland.

The key economic benefits of the project include:

- Direct employment of up to 3,892 persons during the construction phase, and up to 3,391 persons during the operations phase;
- Creation of substantial indirect employment in Queensland during the construction and operations phases;
- The addition of up to $1.5 billion annually to the gross state product of Queensland; and
- The payment of an annual average of $188 million to the Queensland Government in the form of royalty payments.

4.16.3 Consequences of Not Proceeding with the Project

The consequences of the project not proceeding are:

- The opportunity to mine a substantial coal resource would be lost;
- The opportunities provided by the project to maintain and develop Australia's market share in the global thermal coal market would be lost;
- The royalty charges and other government levies, coal freight and port opportunities associated with the project would be lost;
- The contribution of the project to the state economy would not eventuate;
- The employment opportunities provided by the project would not eventuate;
- The project's environmental impacts specified in this EIS would not eventuate;
- The significant socio-economic benefits associated with the development of the project would be forgone; and
- The project's significant contribution to the economic feasibility of the development of the Galilee Basin would be lost.

FIGURES

PROJECT CHINA STONE

MACMINES AUSTASIA

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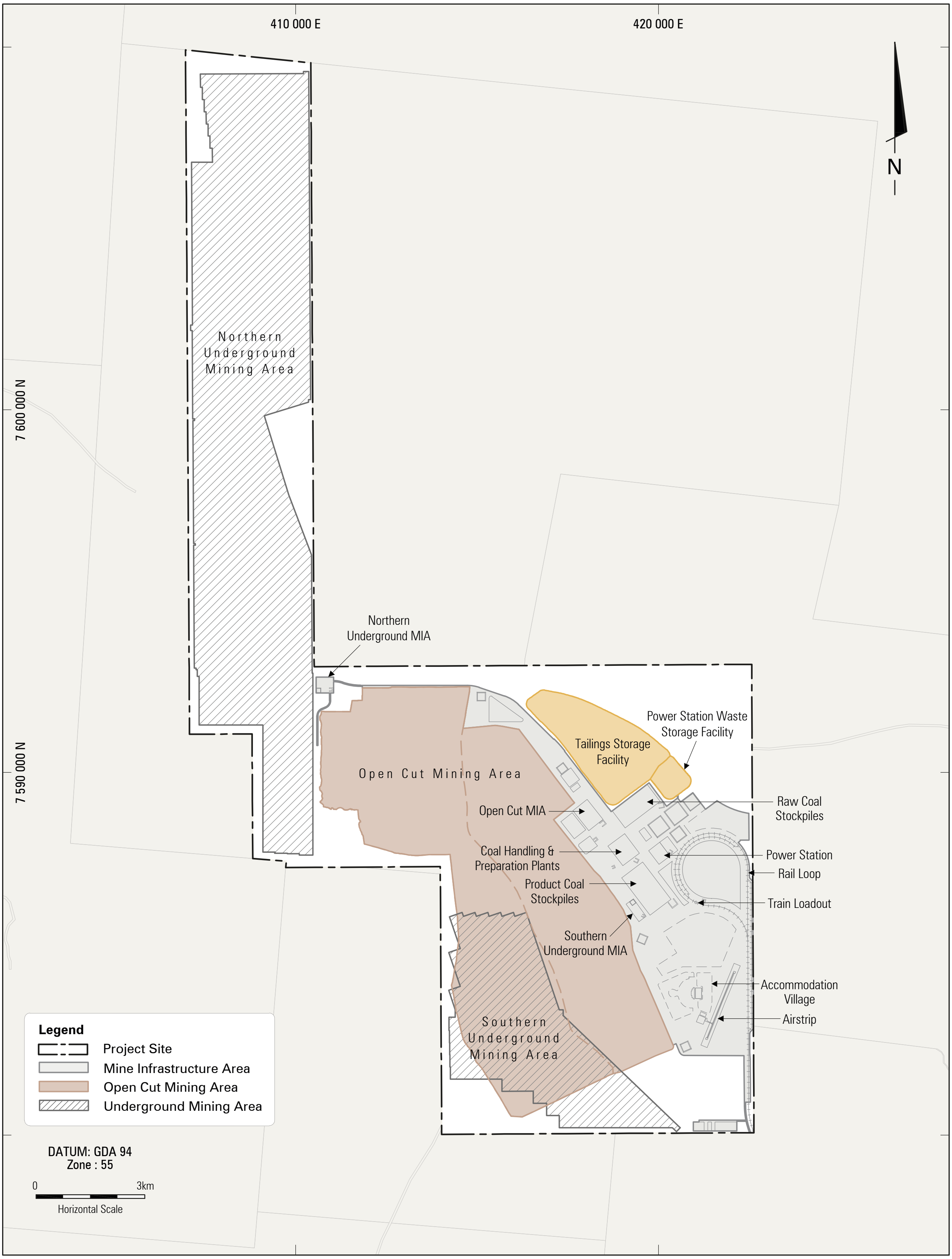
Project Location

FIGURE 4-1



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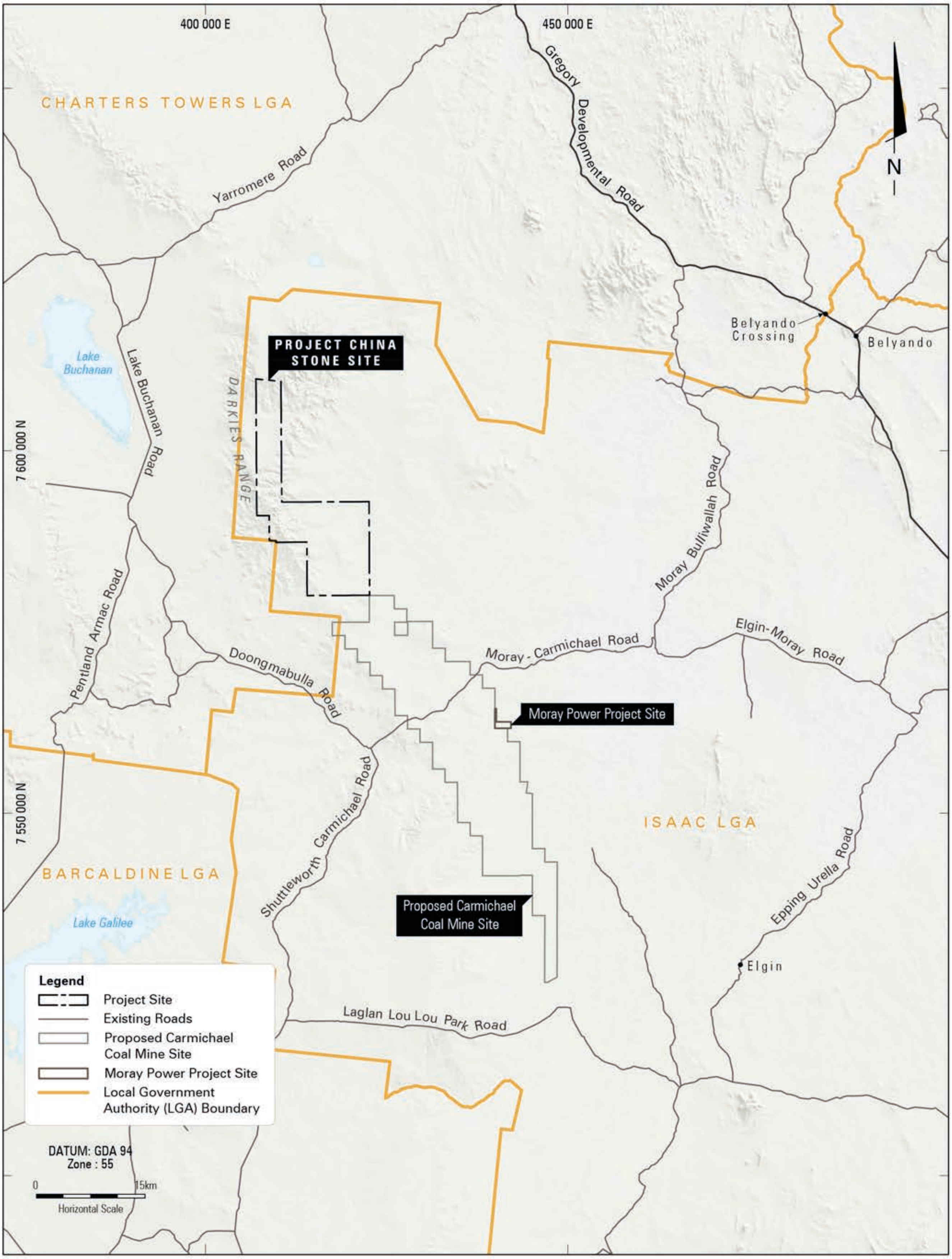
Project Layout

FIGURE 4-2



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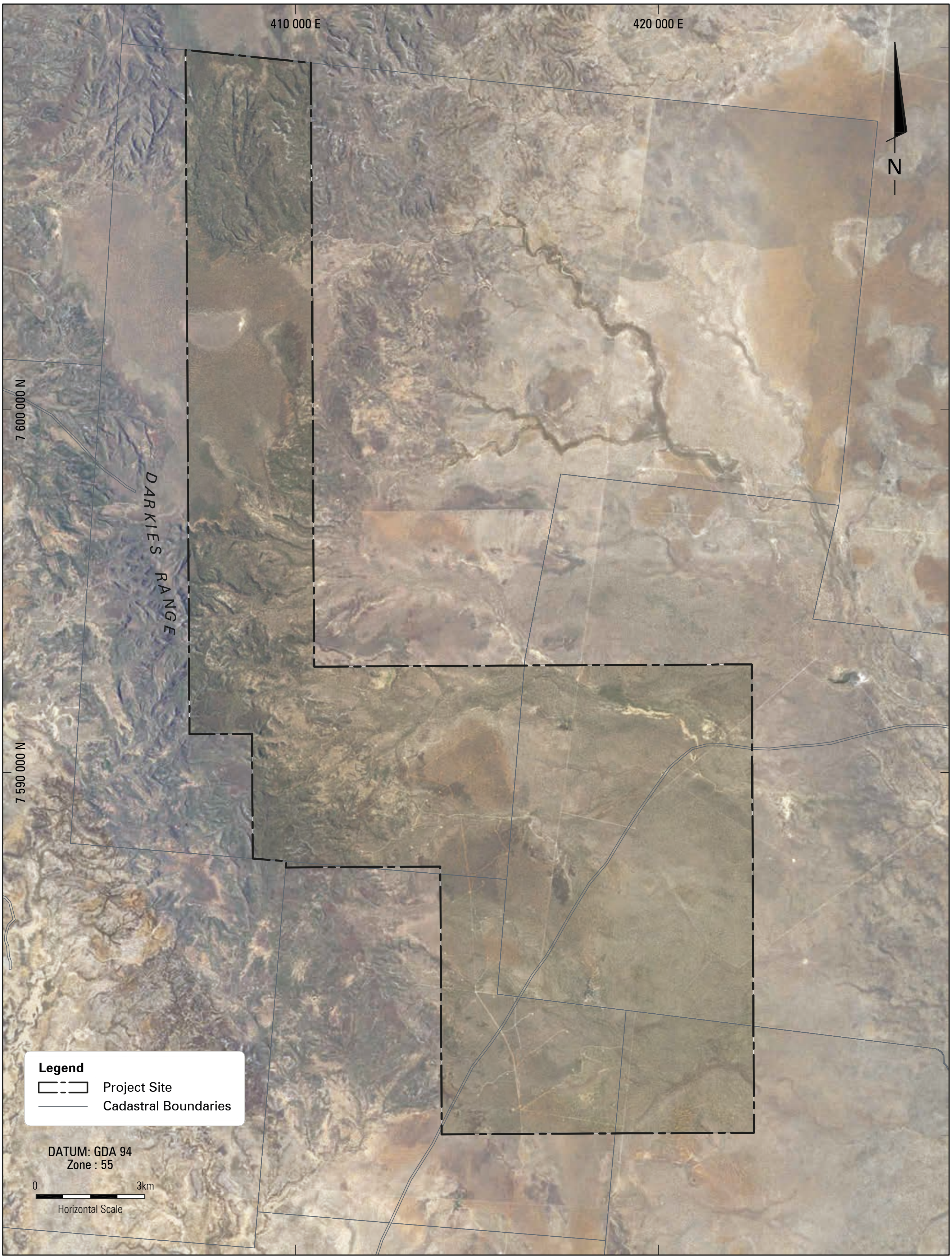
Local Setting

FIGURE 4-3



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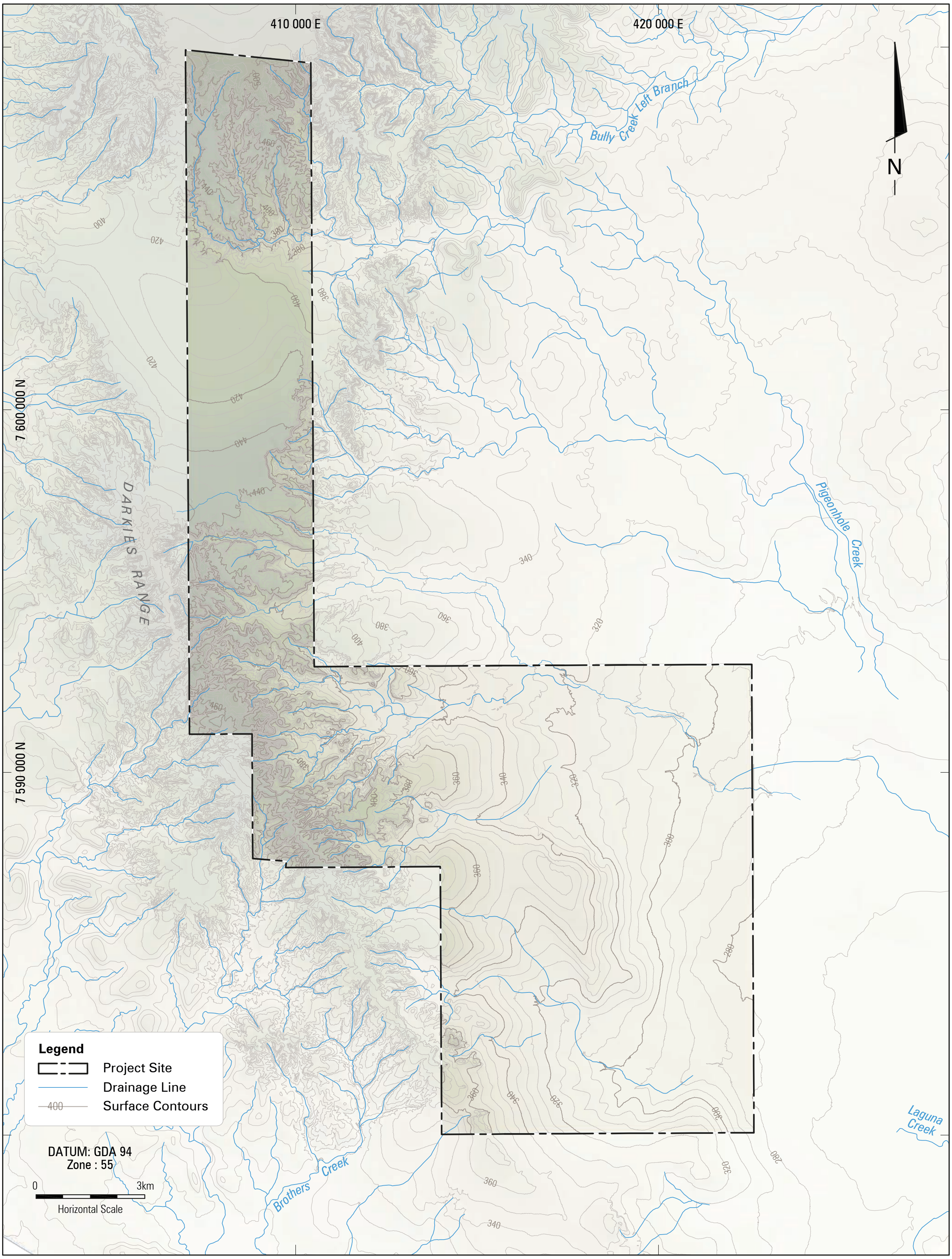
Site Air Photo

FIGURE 4-4



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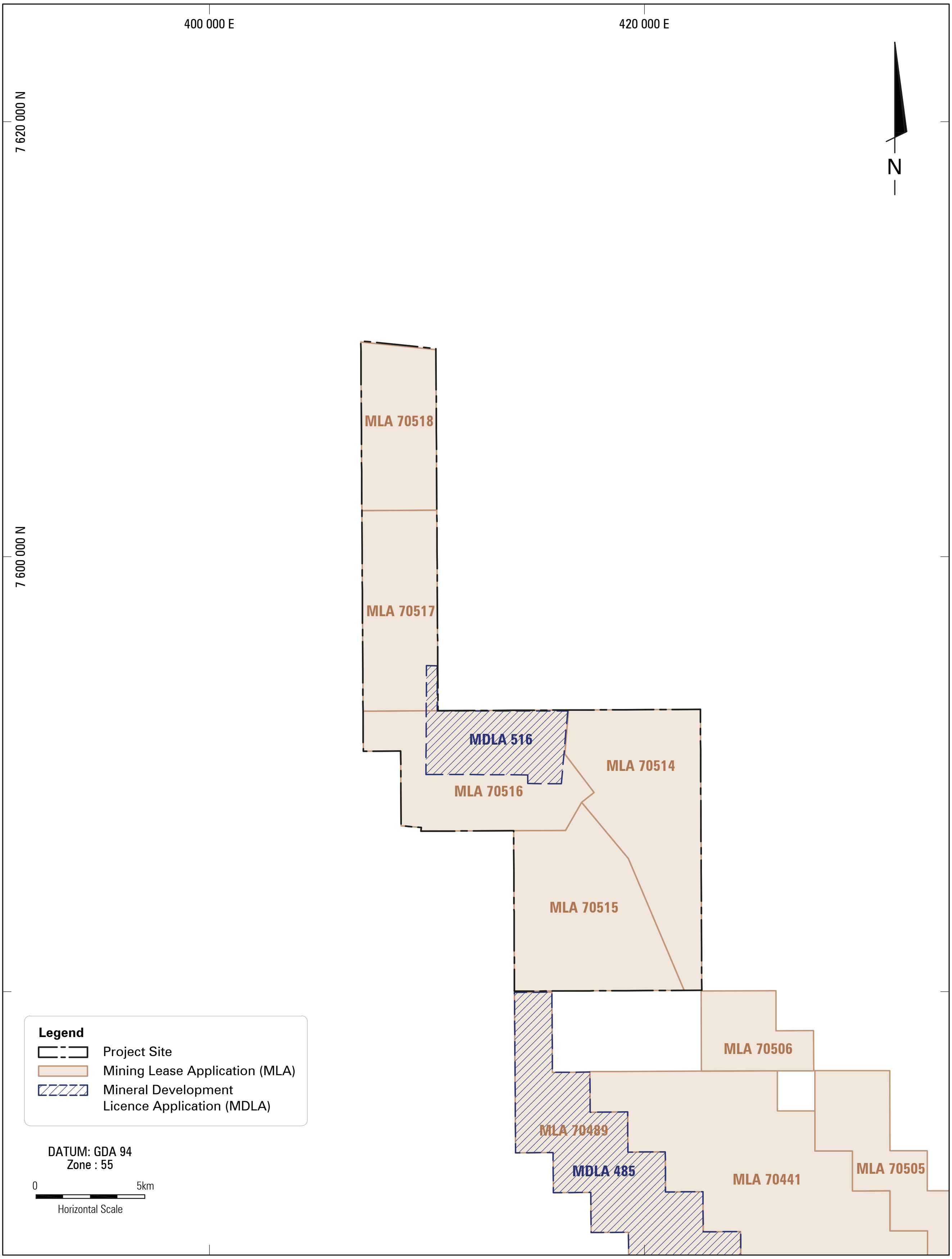
Site Contour Plan

FIGURE 4-5



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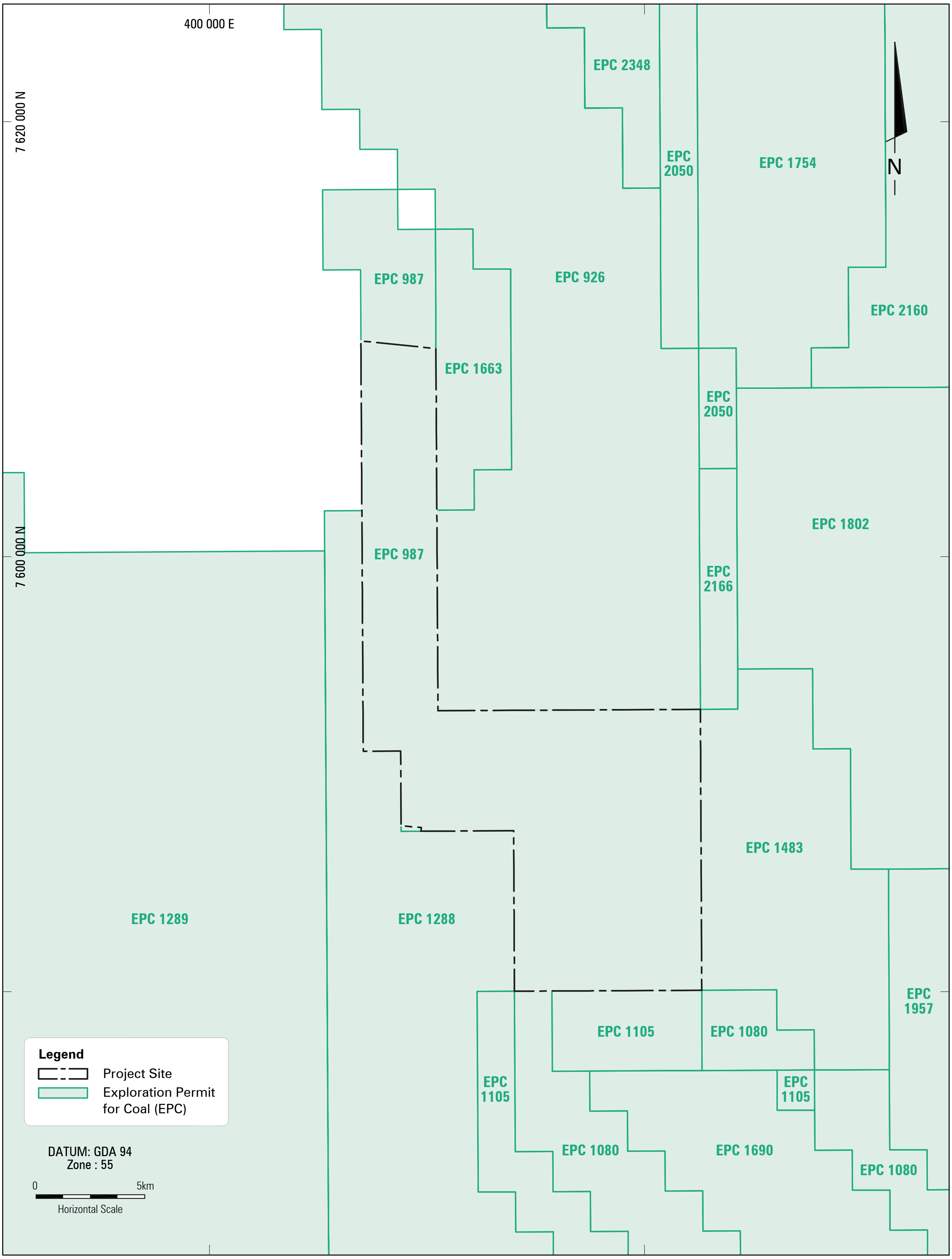
Coal Tenements

FIGURE 4-6



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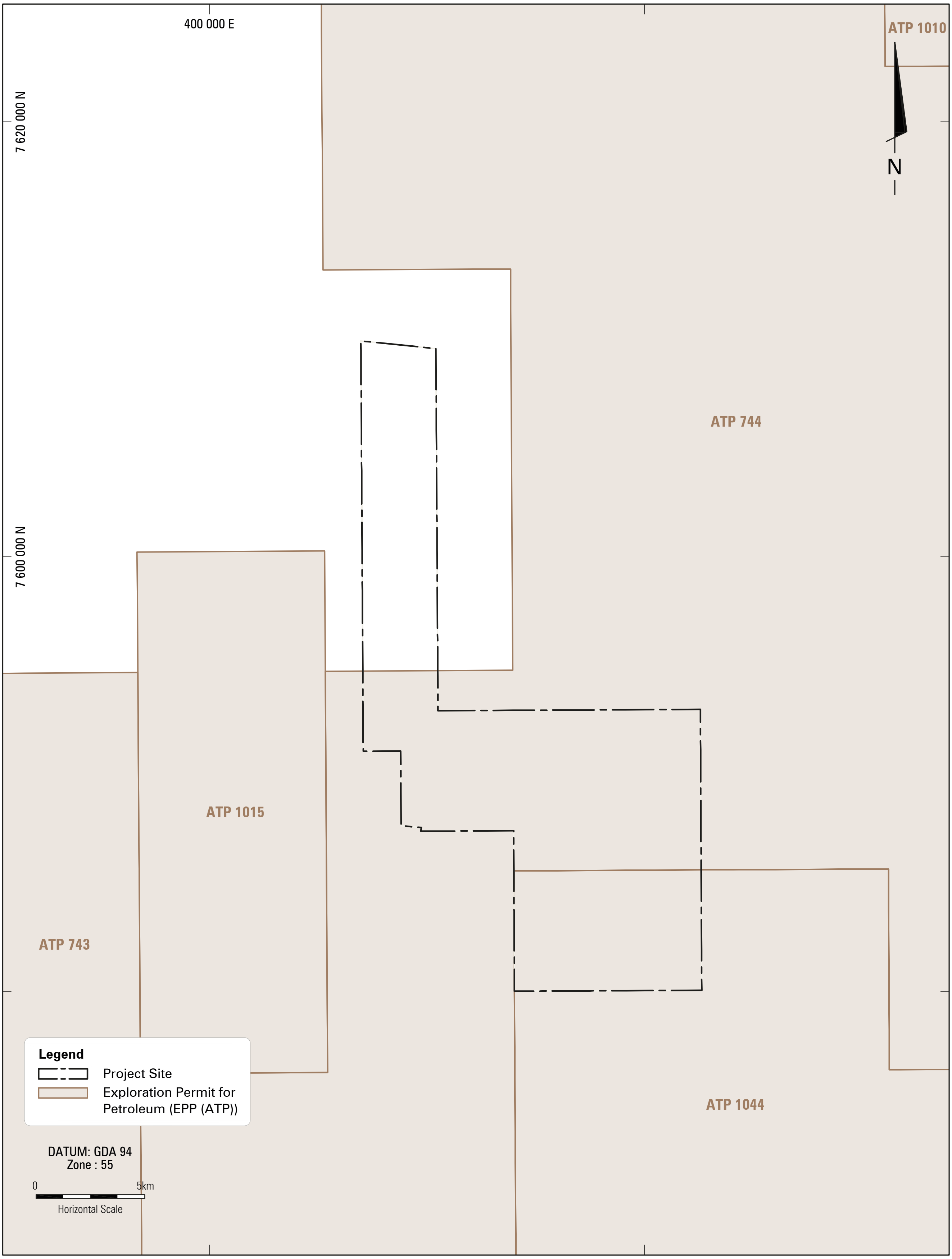
Exploration Permits for Coal

FIGURE 4-7



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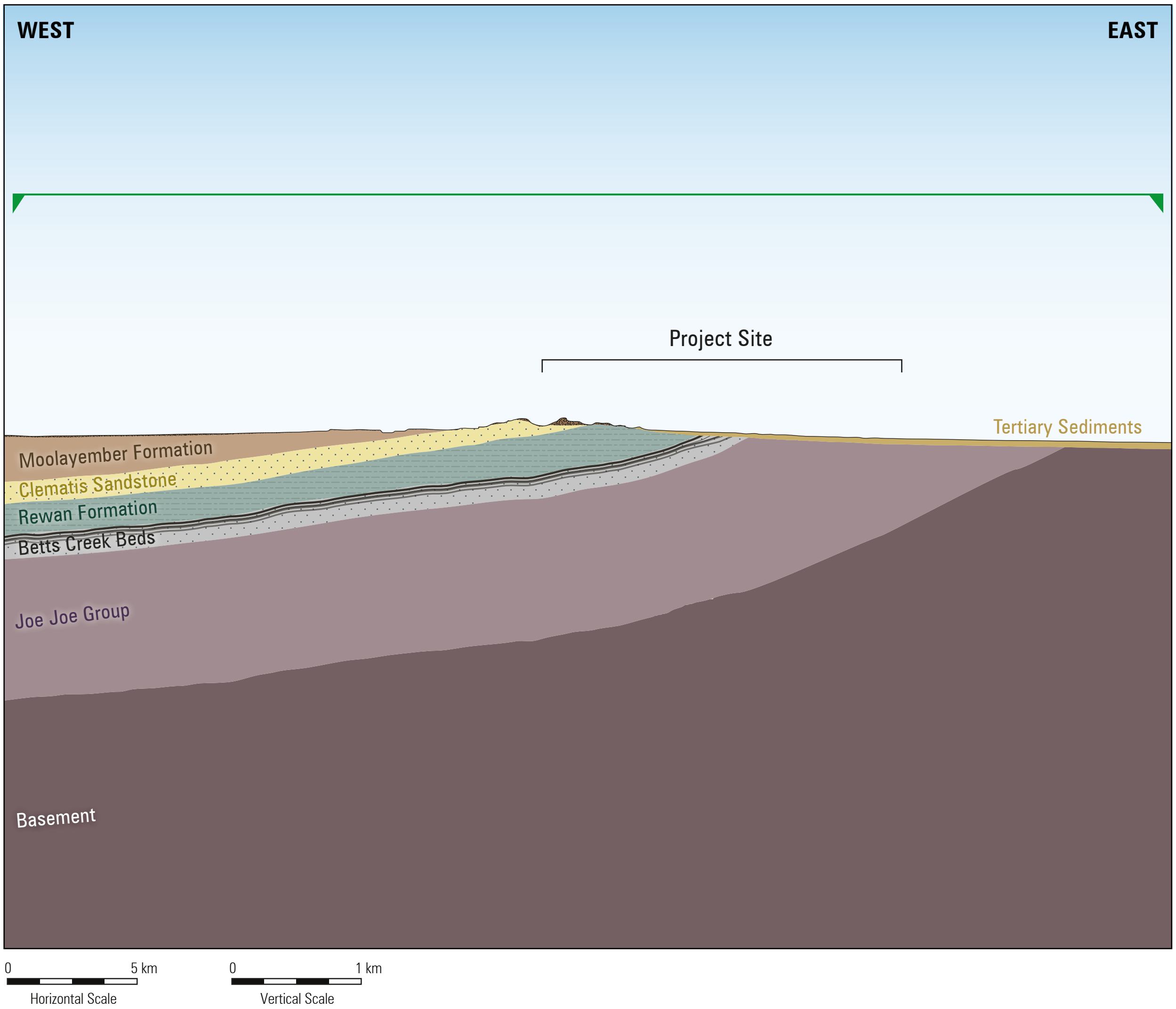
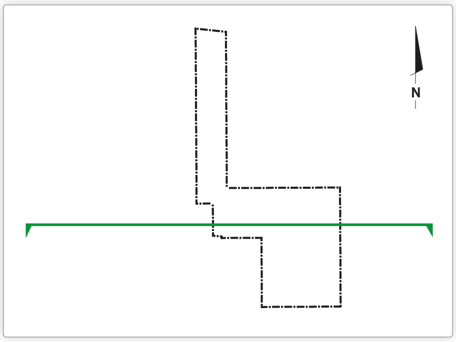
Exploration Permits for Petroleum

FIGURE 4-8



Legend

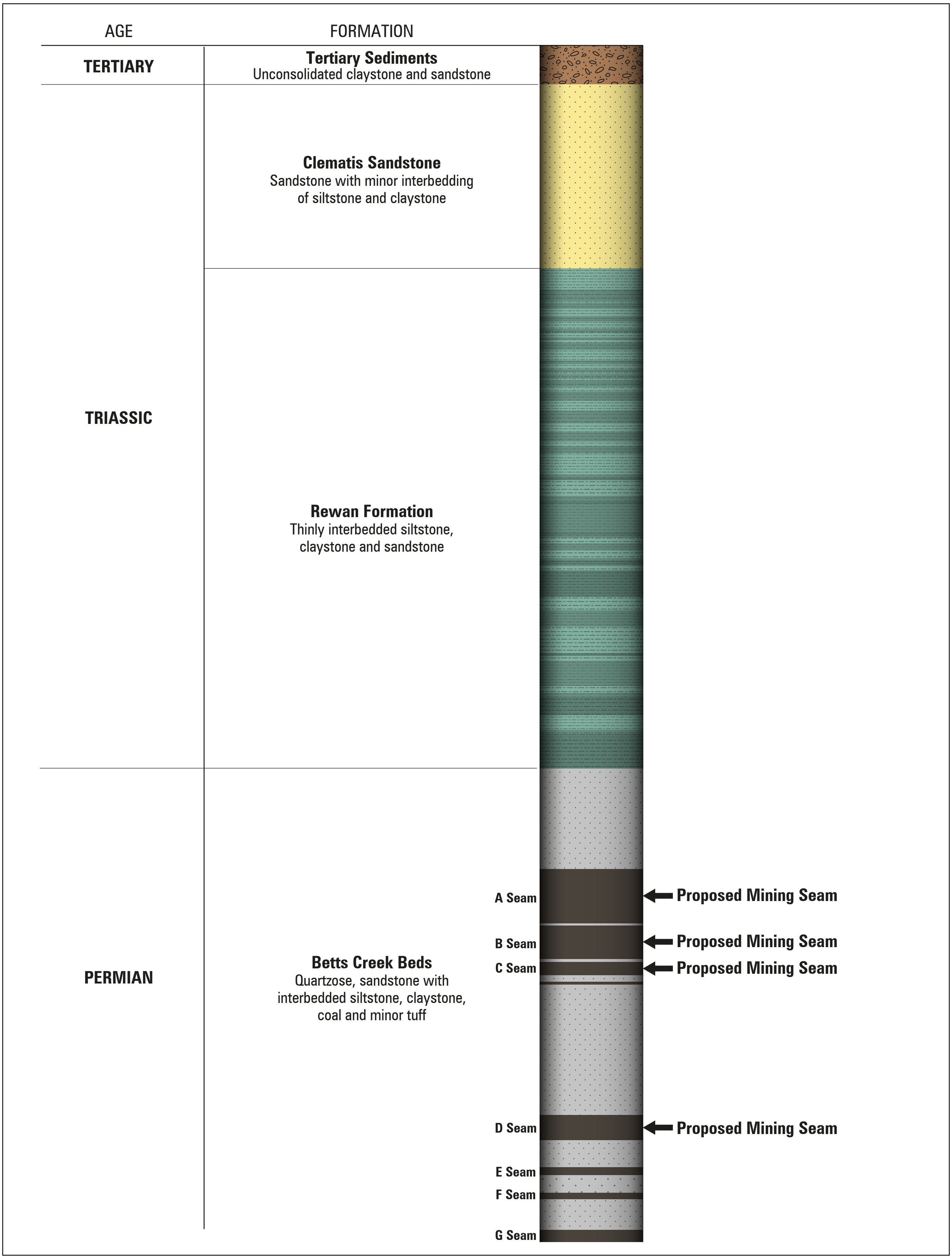
	Basin	Age	Stratigraphic Unit
🟨		Tertiary	Tertiary Sediments
🟫	Galilee	Mid-Triassic	Moolayember Formation
🟨		Mid-Triassic	Clematis Sandstone
🟩		Early-Triassic	Rewan Formation
⬜		Late Permian	Betts Creek Beds
🟪		Early Permian	Joe Joe Group
🟫	Drummond	Late Carboniferous - Early Permian	Basement



PROJECT CHINA STONE

Regional Geology Section

FIGURE 4-9



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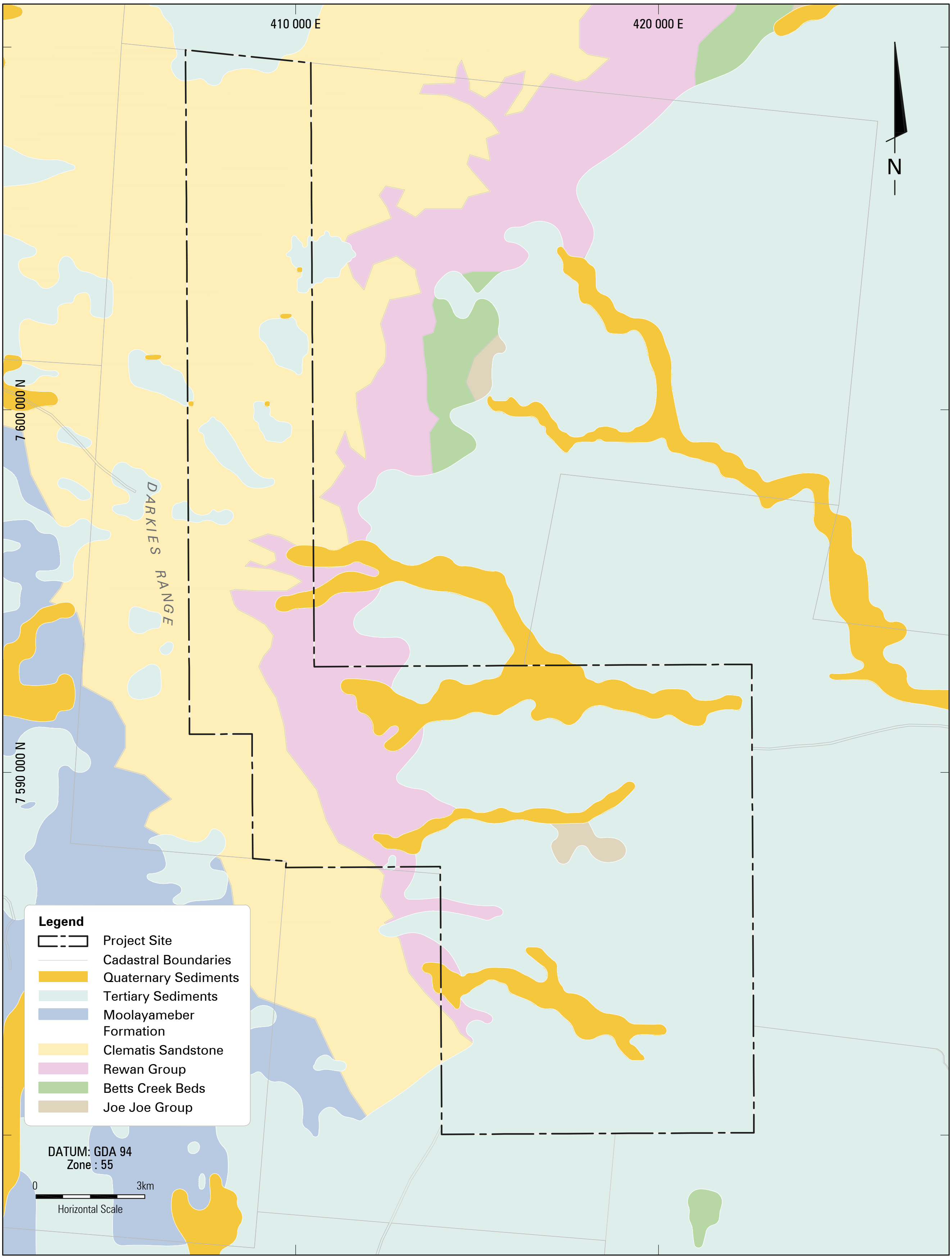
Indicative Site Stratigraphy

FIGURE 4-10



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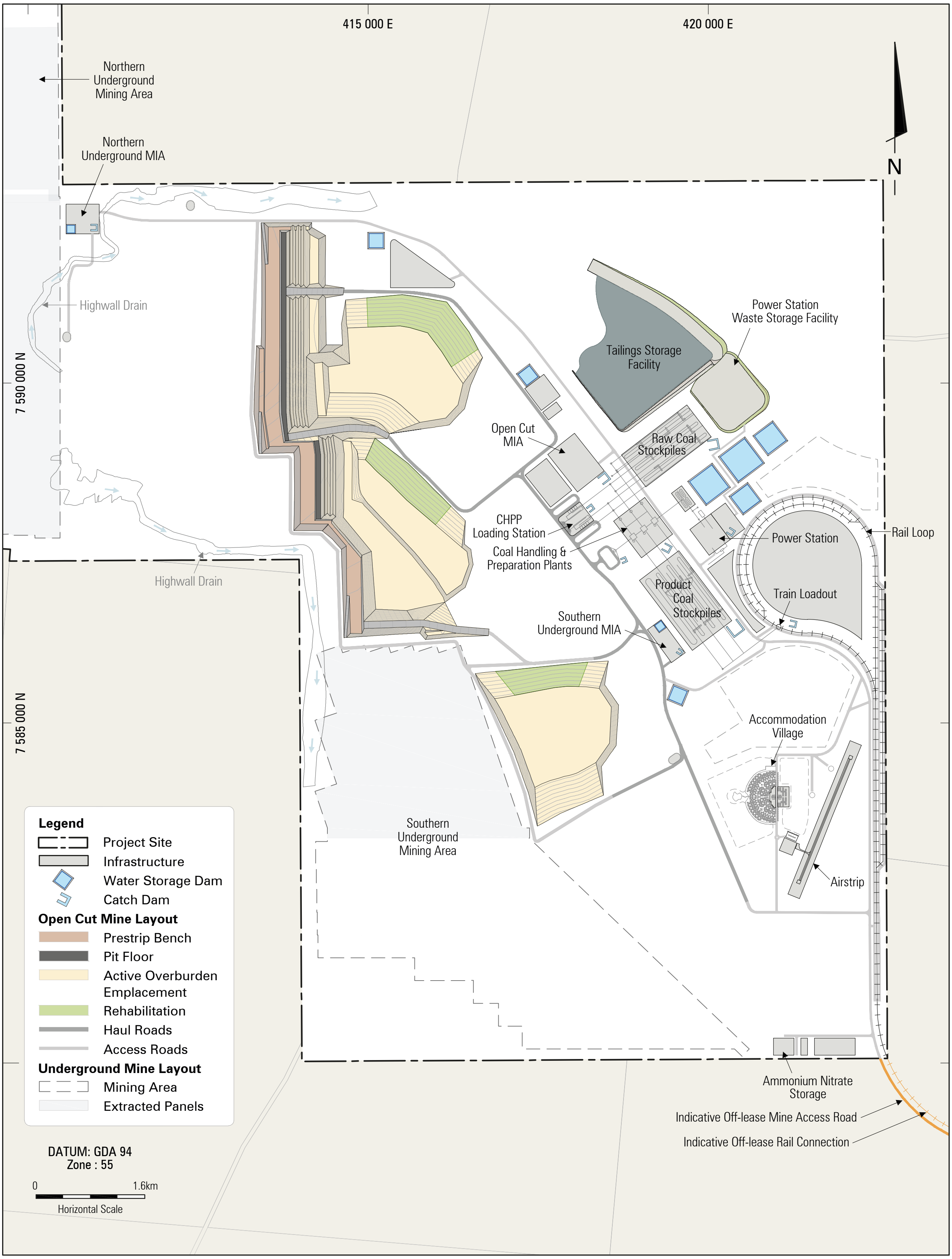
Surface Geology

FIGURE 4-11



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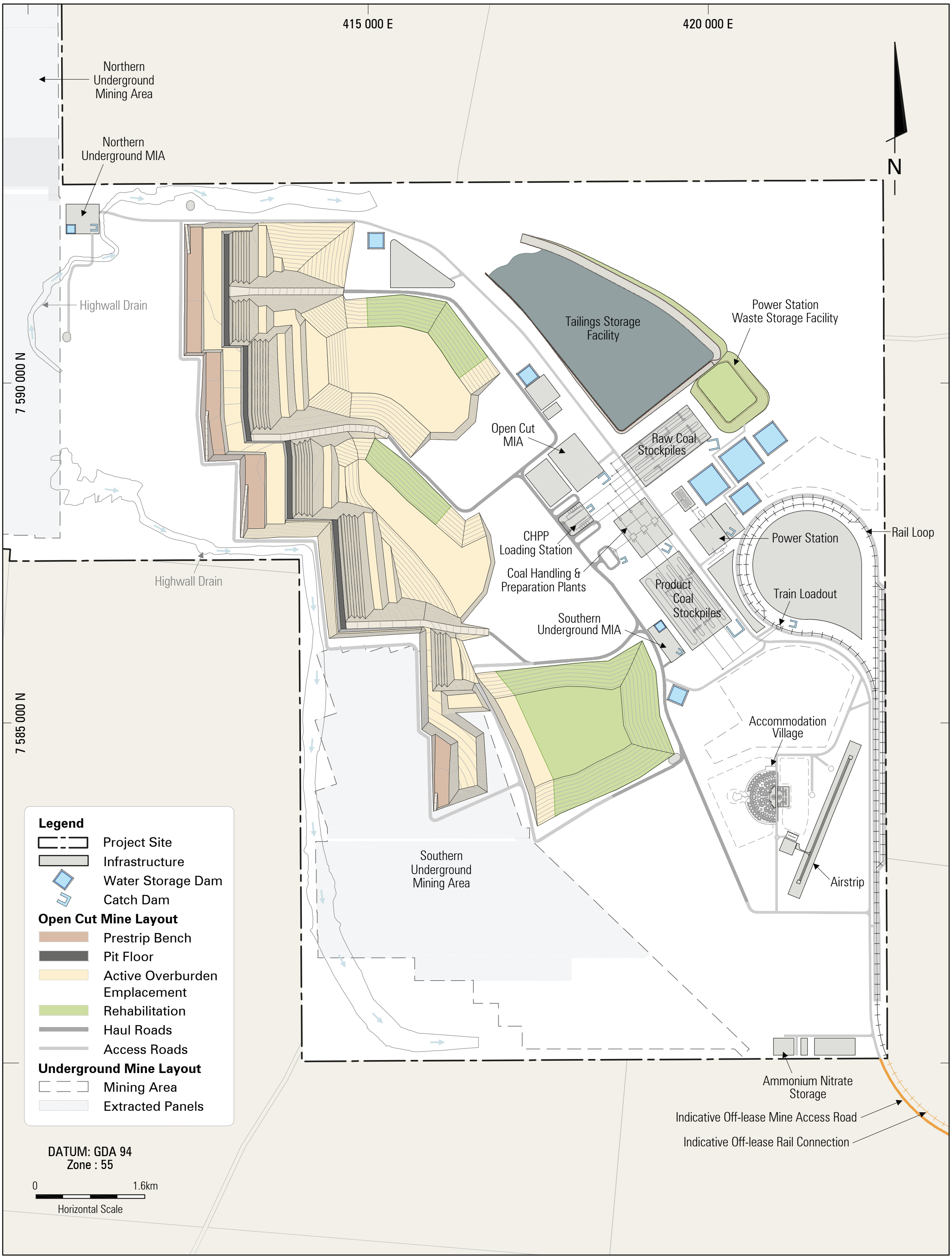
Open Cut Mine Layout - Year 5

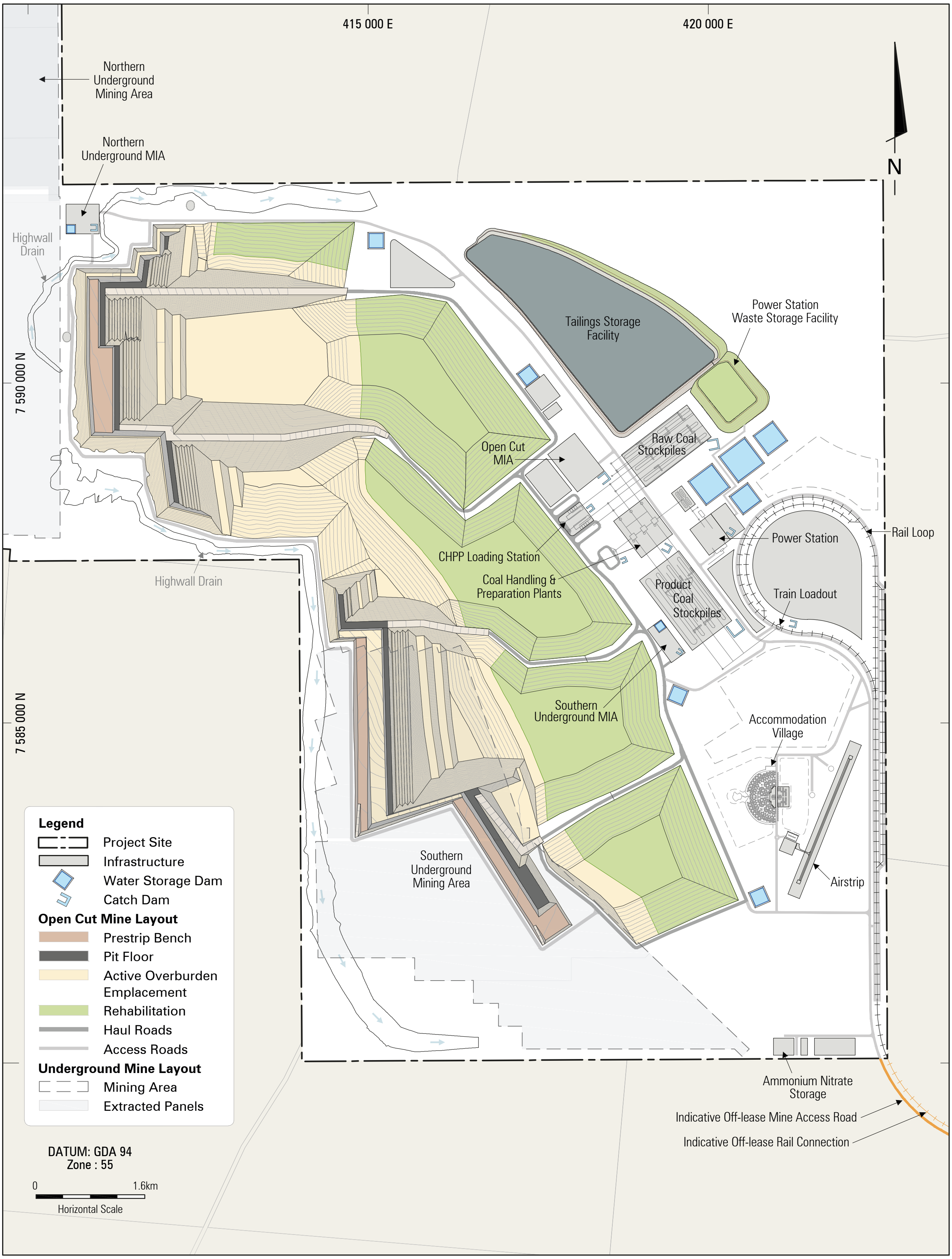
FIGURE 4-12



PROJECT CHINA STONE

Open Cut Mine Layout - Year 10

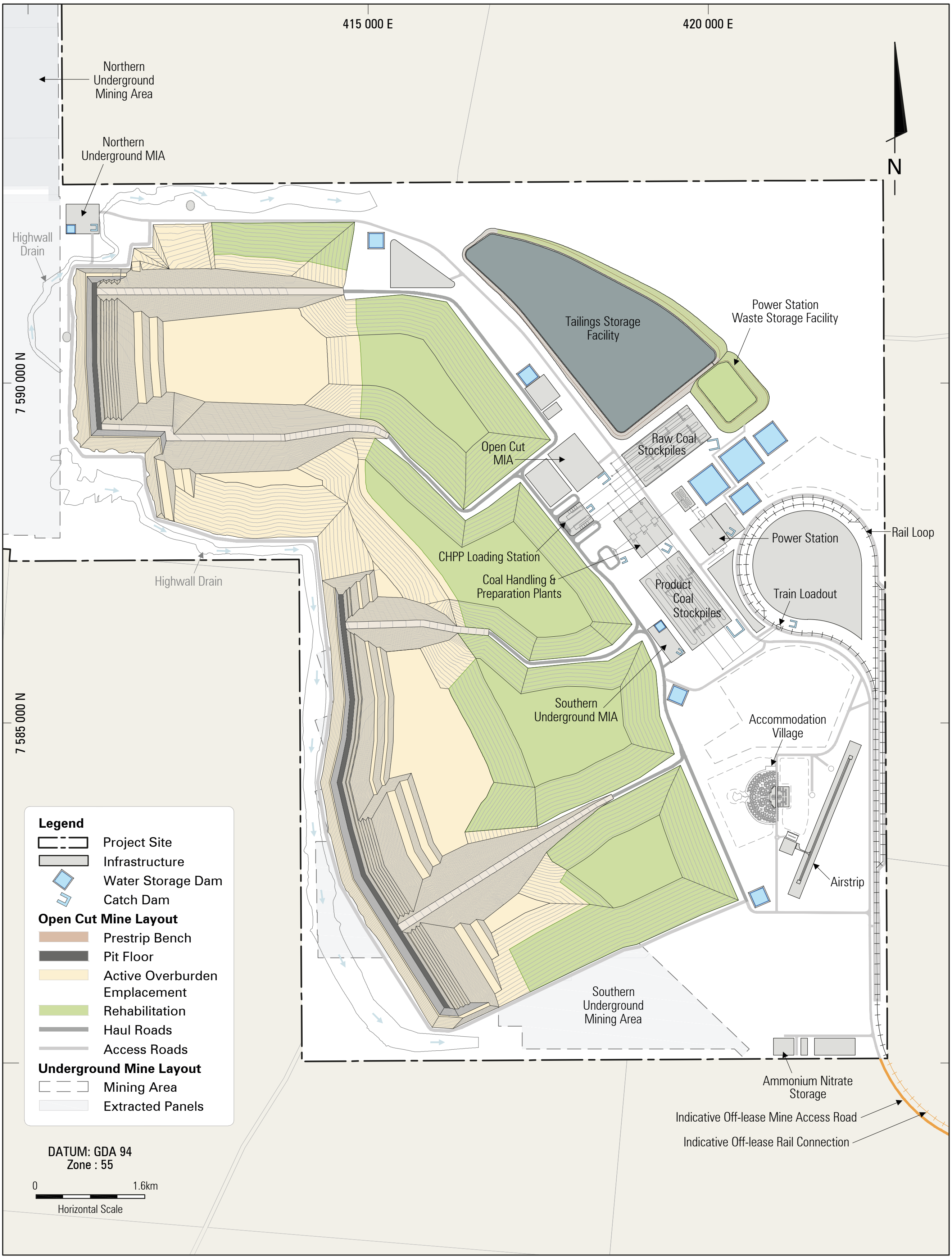
FIGURE 4-13



PROJECT CHINA STONE

Open Cut Mine Layout - Year 20

FIGURE 4-14



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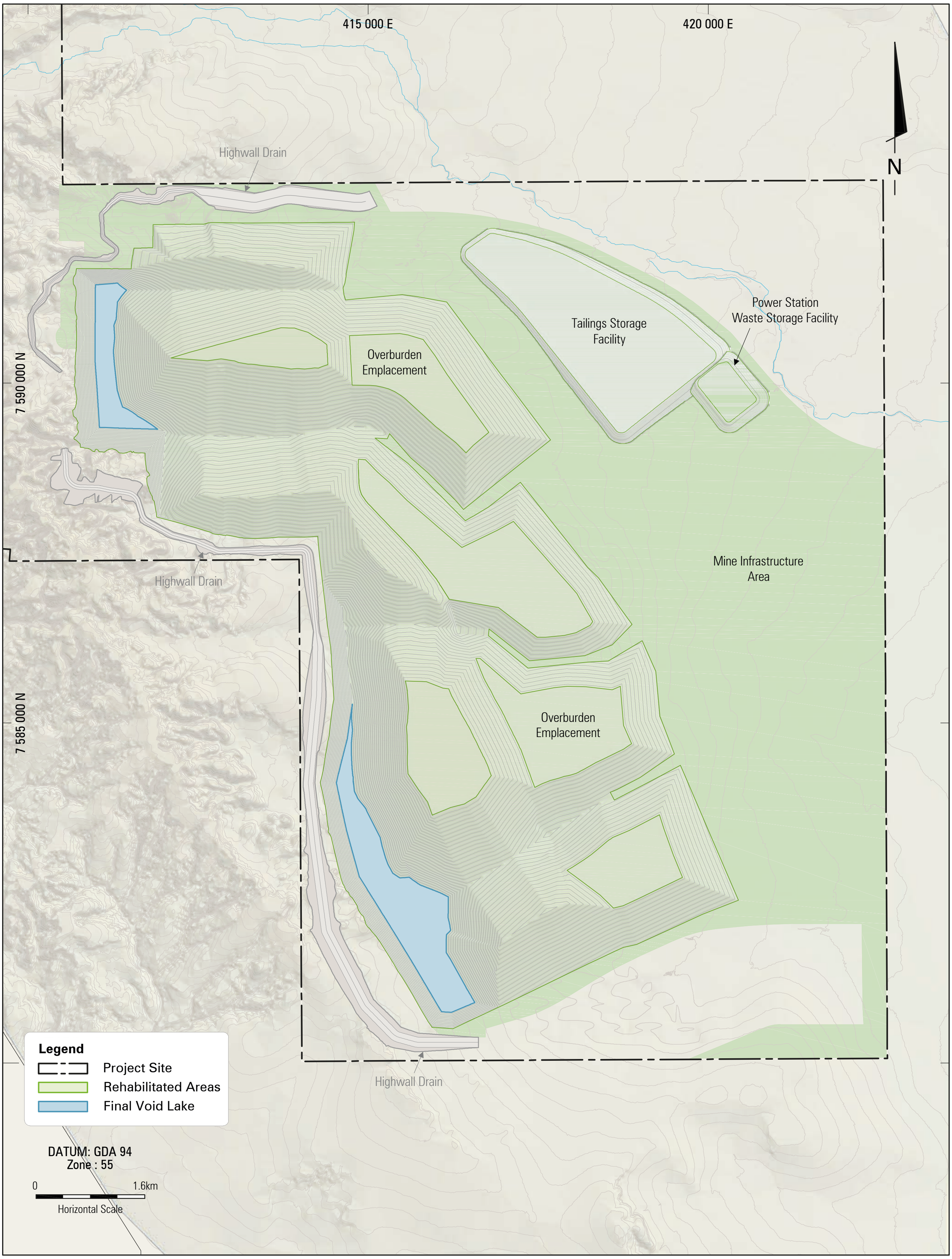
Open Cut Mine Layout - Year 30

FIGURE 4-15



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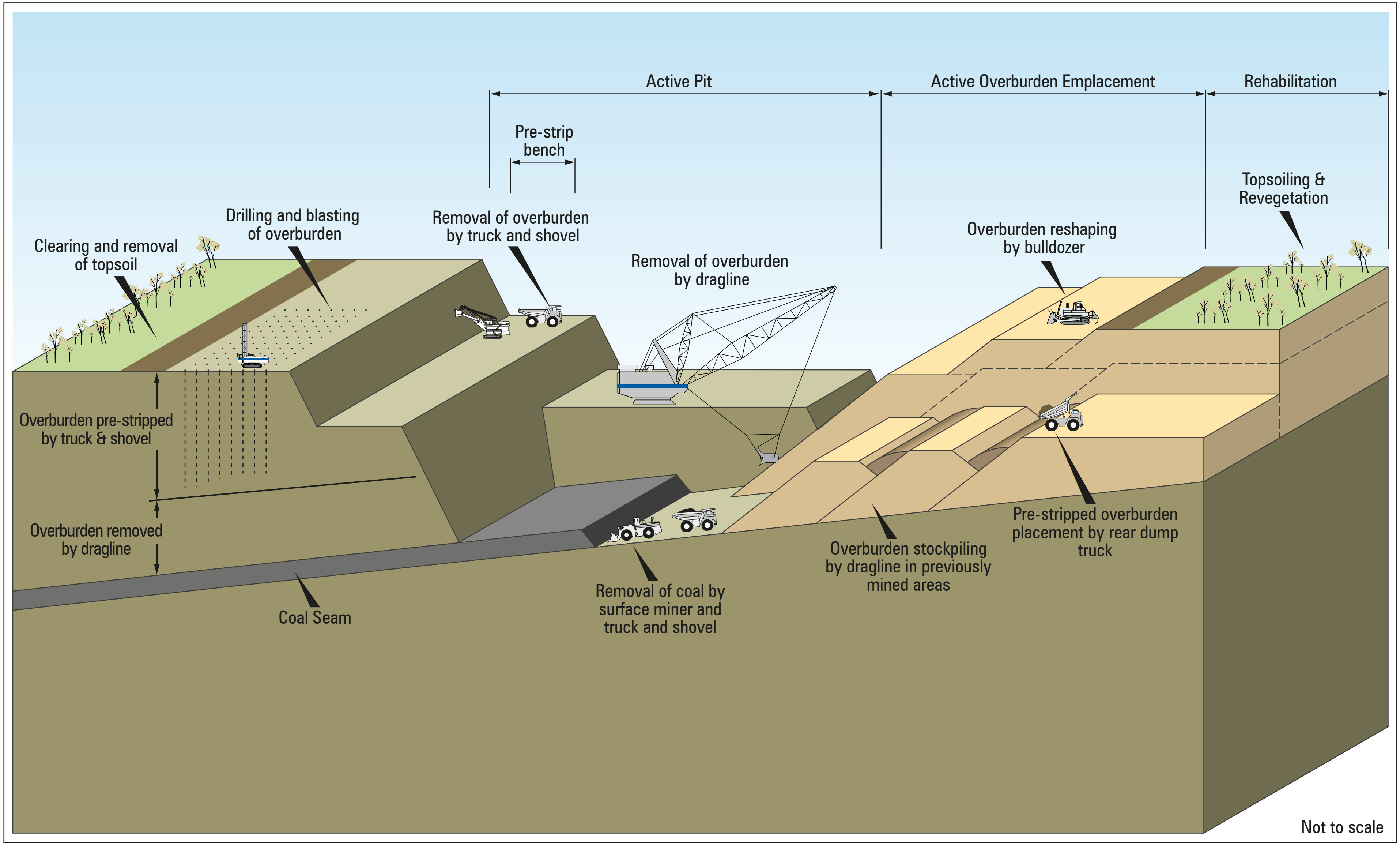
Open Cut Mine Layout - Final Landform

FIGURE 4-16



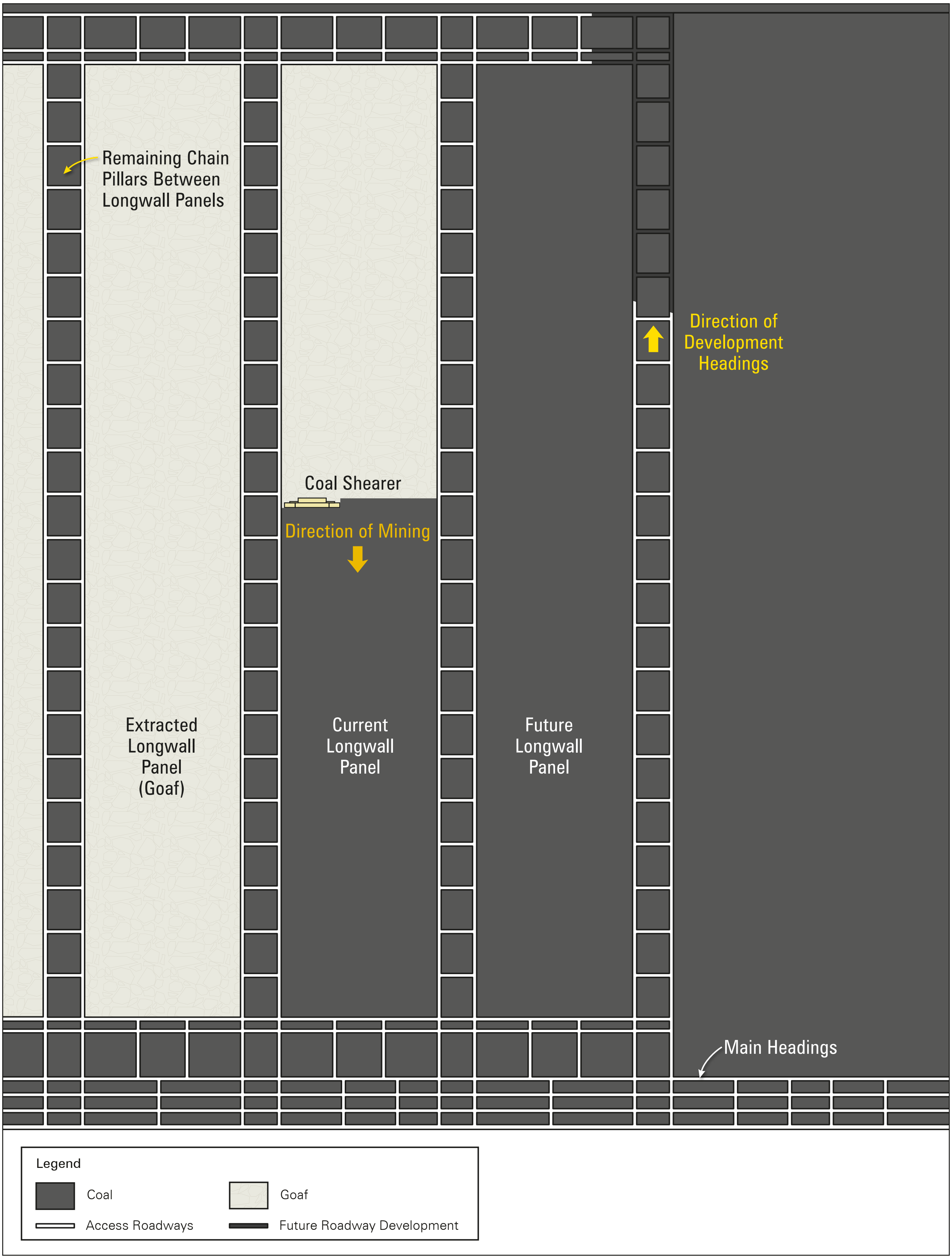
PROJECT CHINA STONE

MACMINES AUSTASIA

Hansen Bailey
ENVIRONMENTAL CONSULTANTS

Open Cut Mining Operations Schematic

FIGURE 4-17



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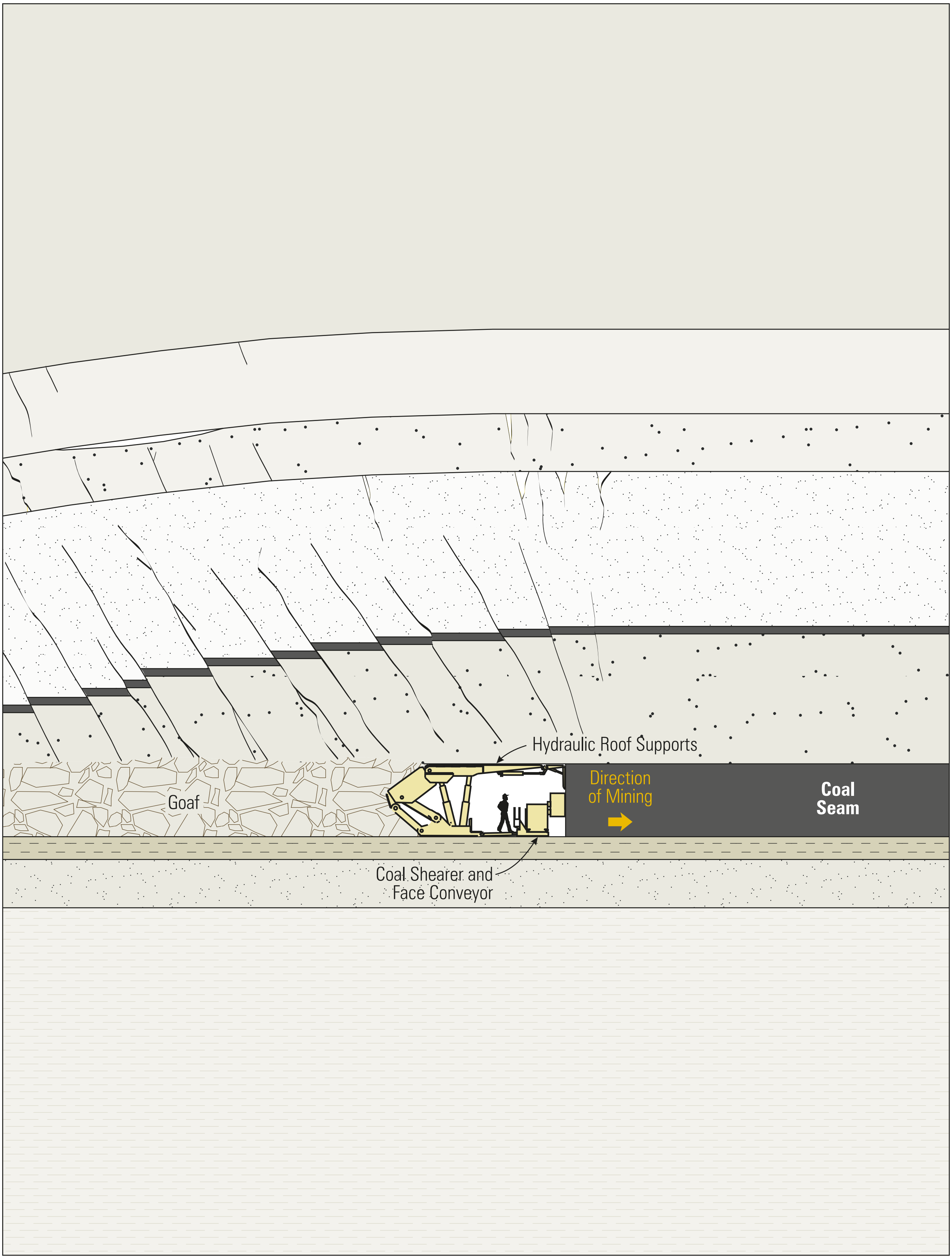
Typical Longwall Layout

FIGURE 4-18



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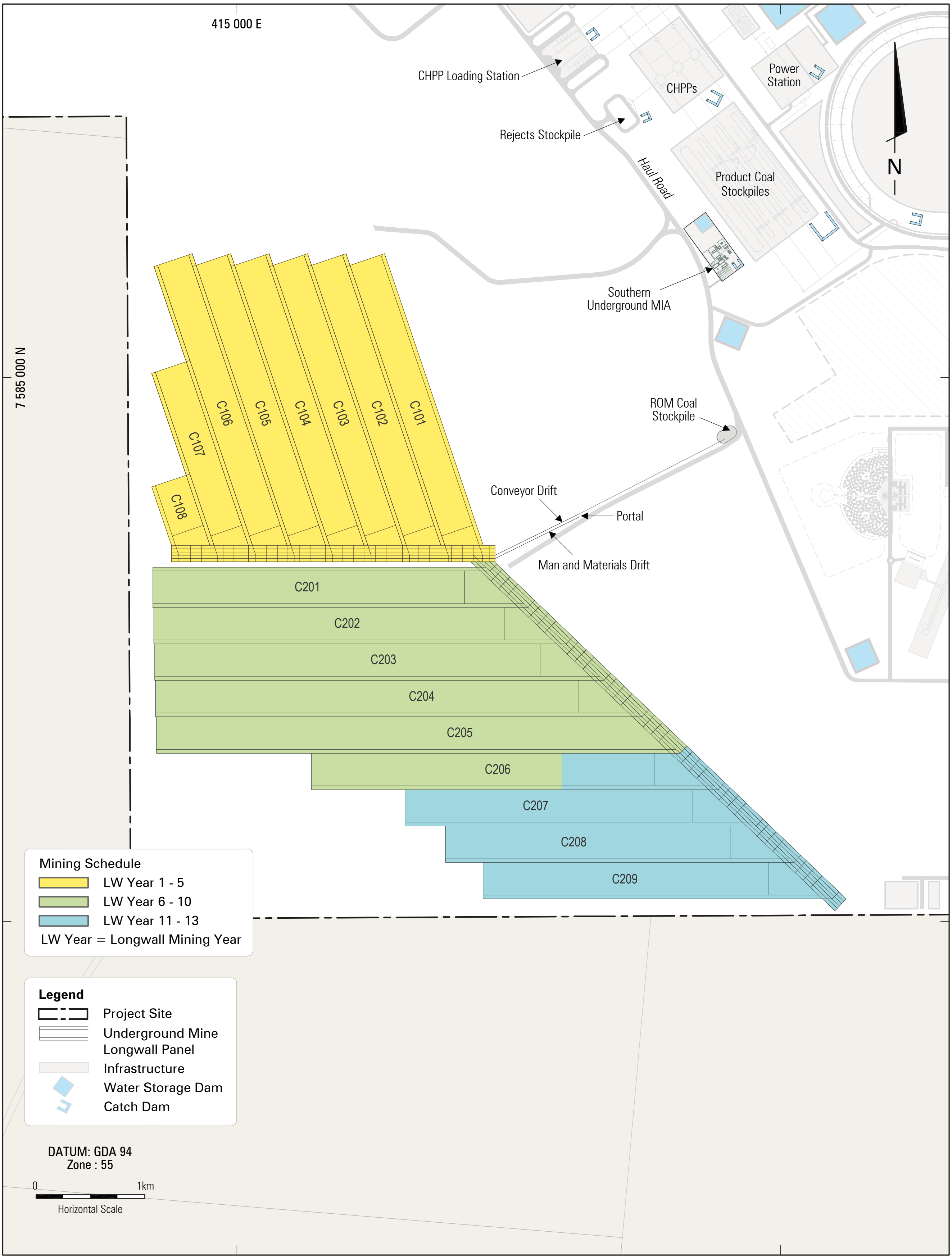
Cross Section Through
Typical Longwall Face

FIGURE 4-19



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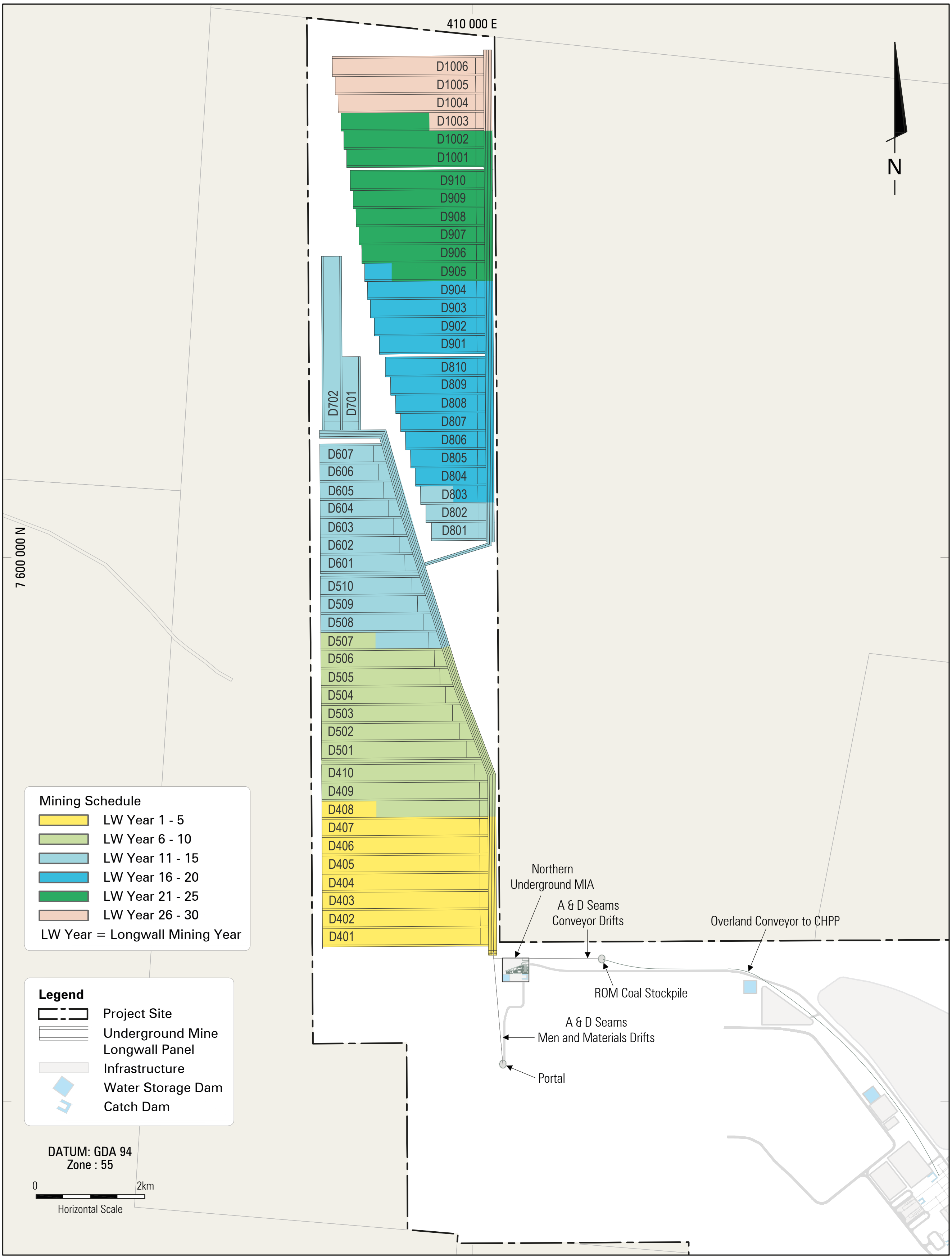
Southern Underground (C Seam)
Mine Layout and Schedule

FIGURE 4-20



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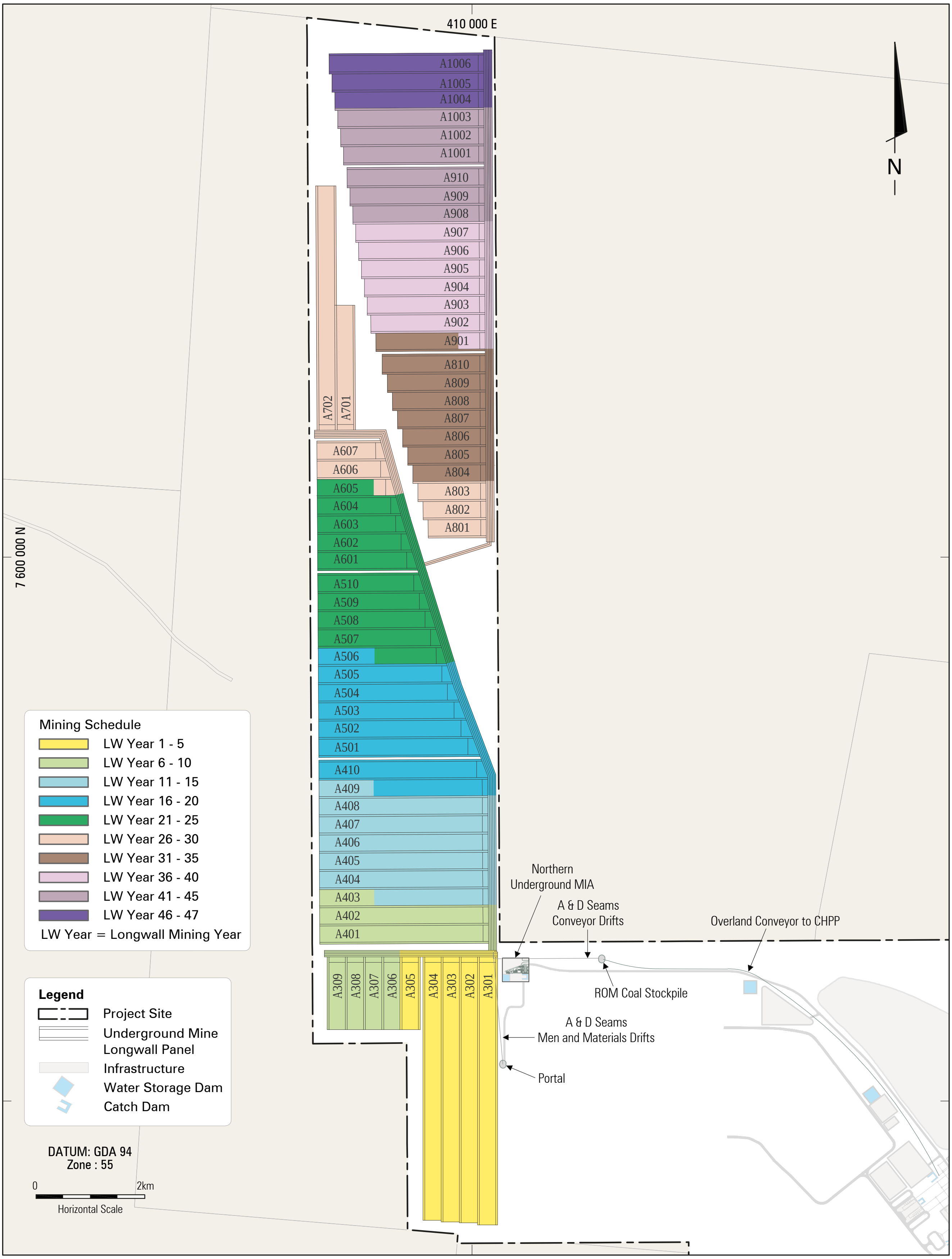
Northern Underground (D Seam)
Mine Layout and Schedule

FIGURE 4-21



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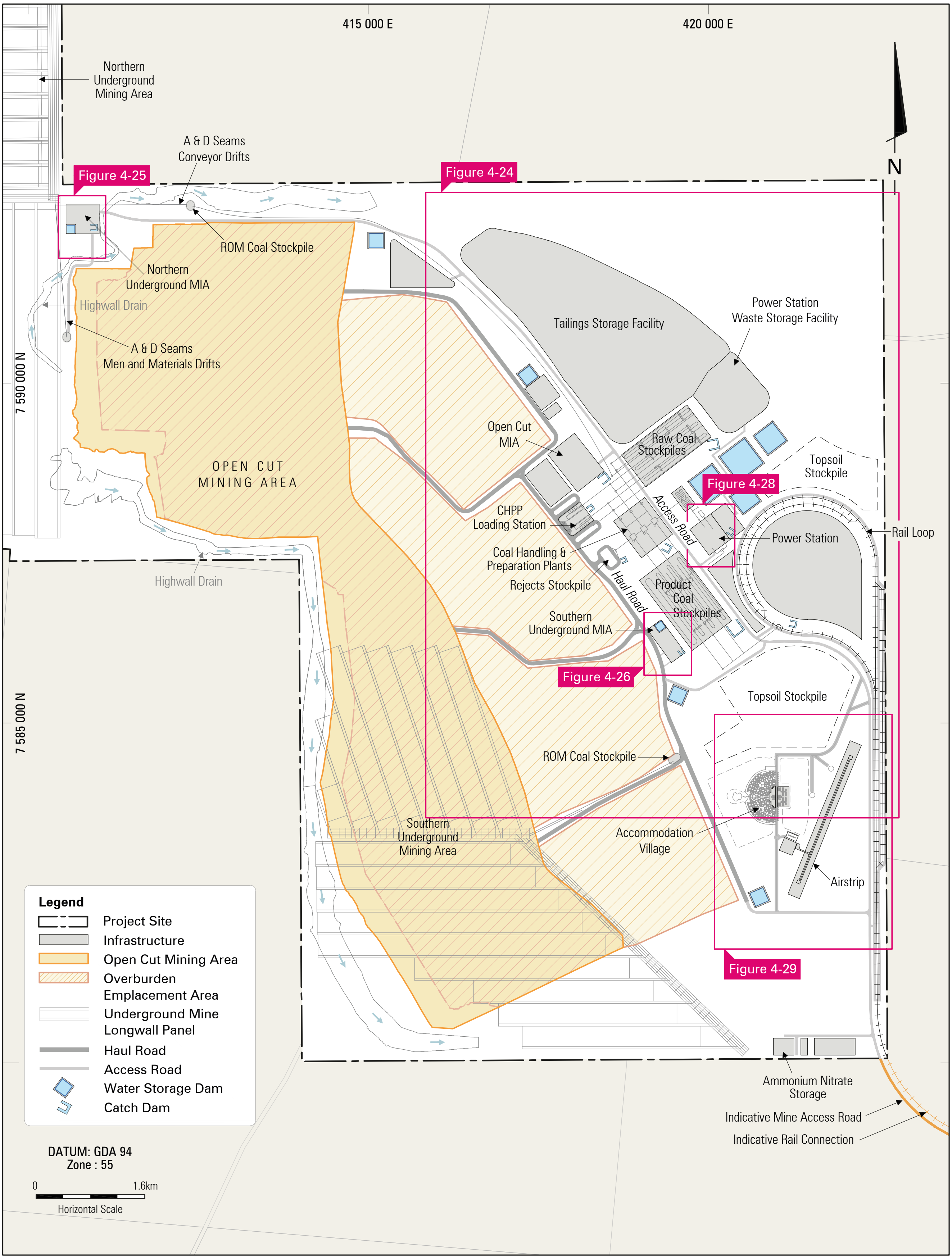
Northern Underground (A Seam)
Mine Layout and Schedule

FIGURE 4-22



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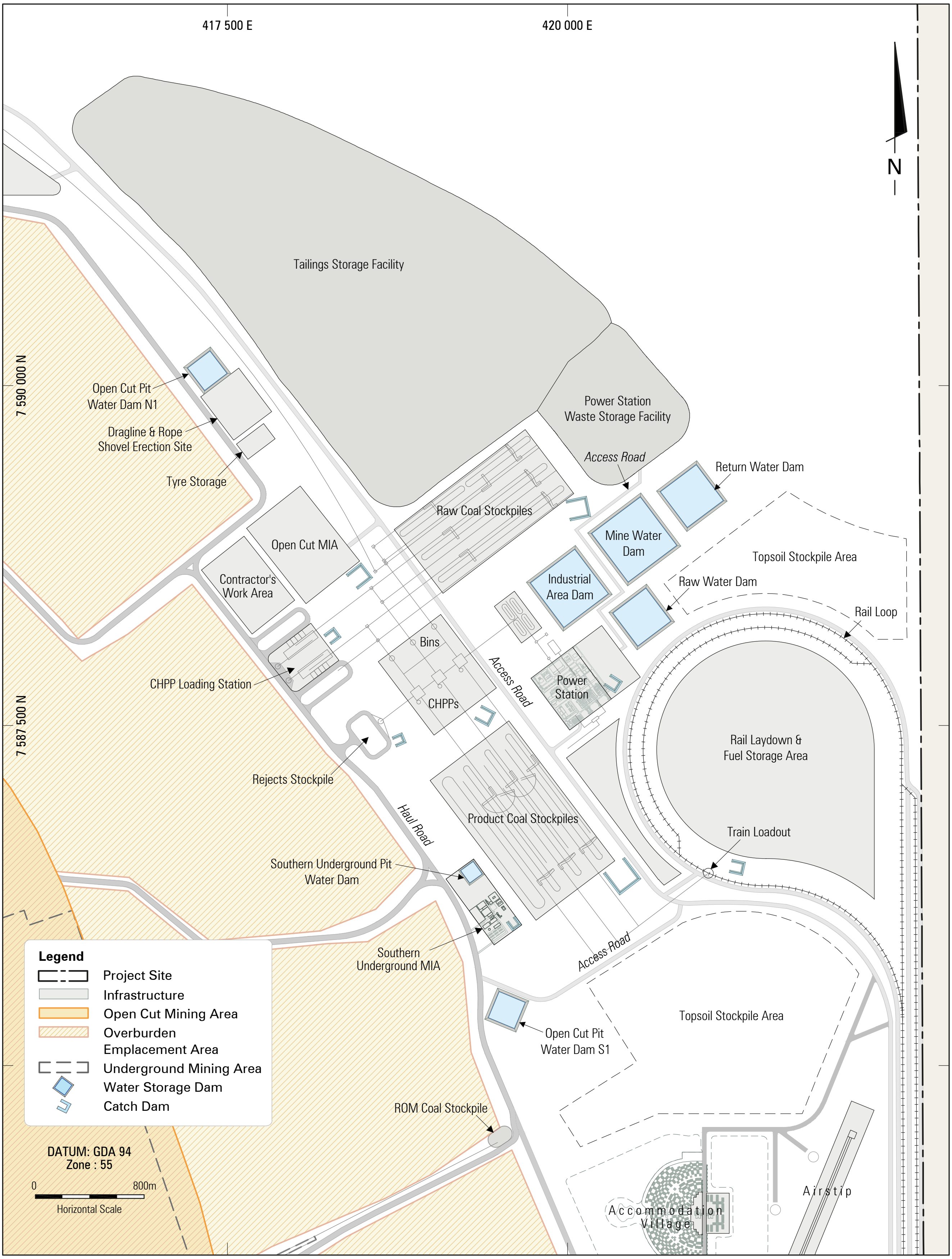
Project Layout - Detail

FIGURE 4-23



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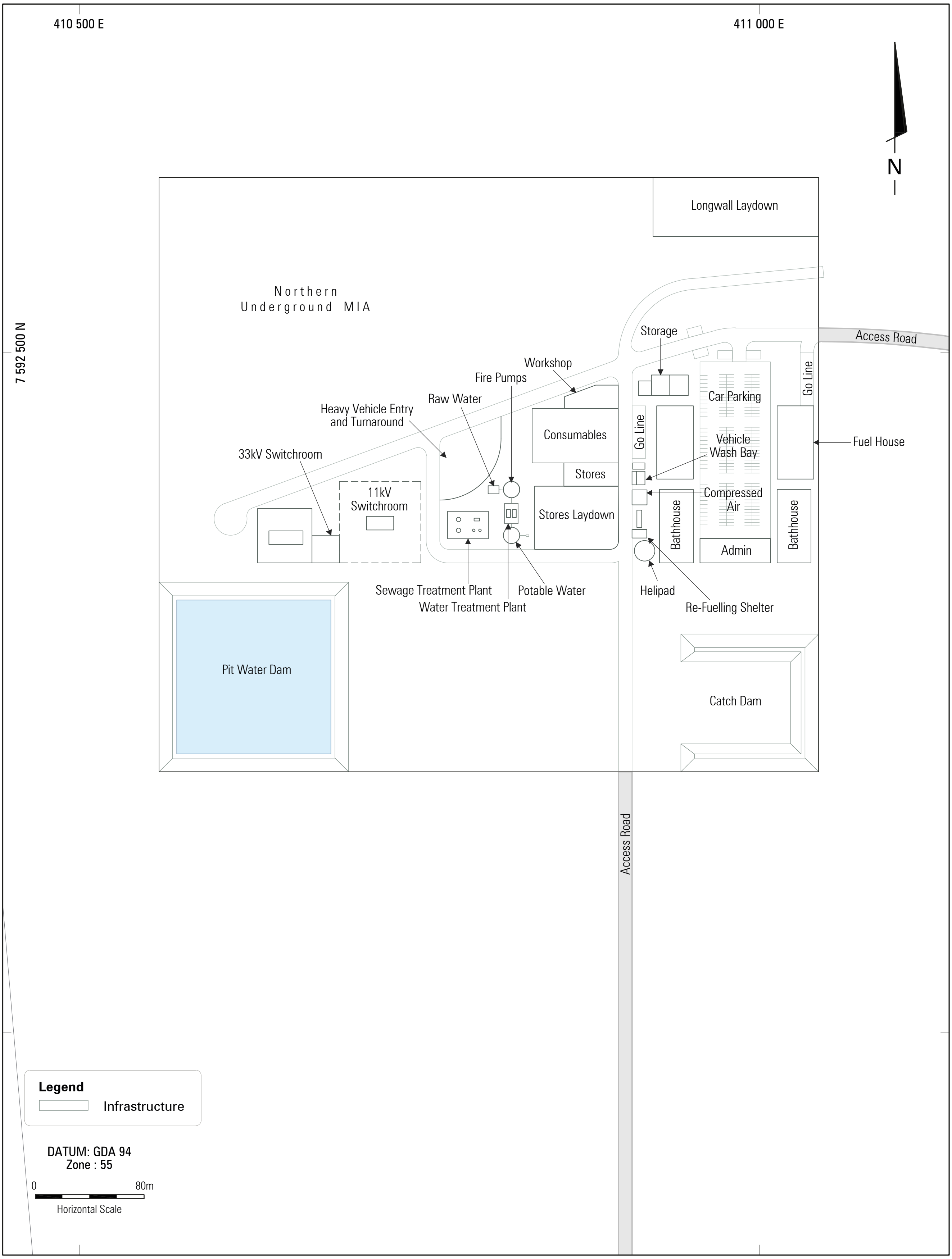
Project Layout -
Central Infrastructure Area Detail

FIGURE 4-24



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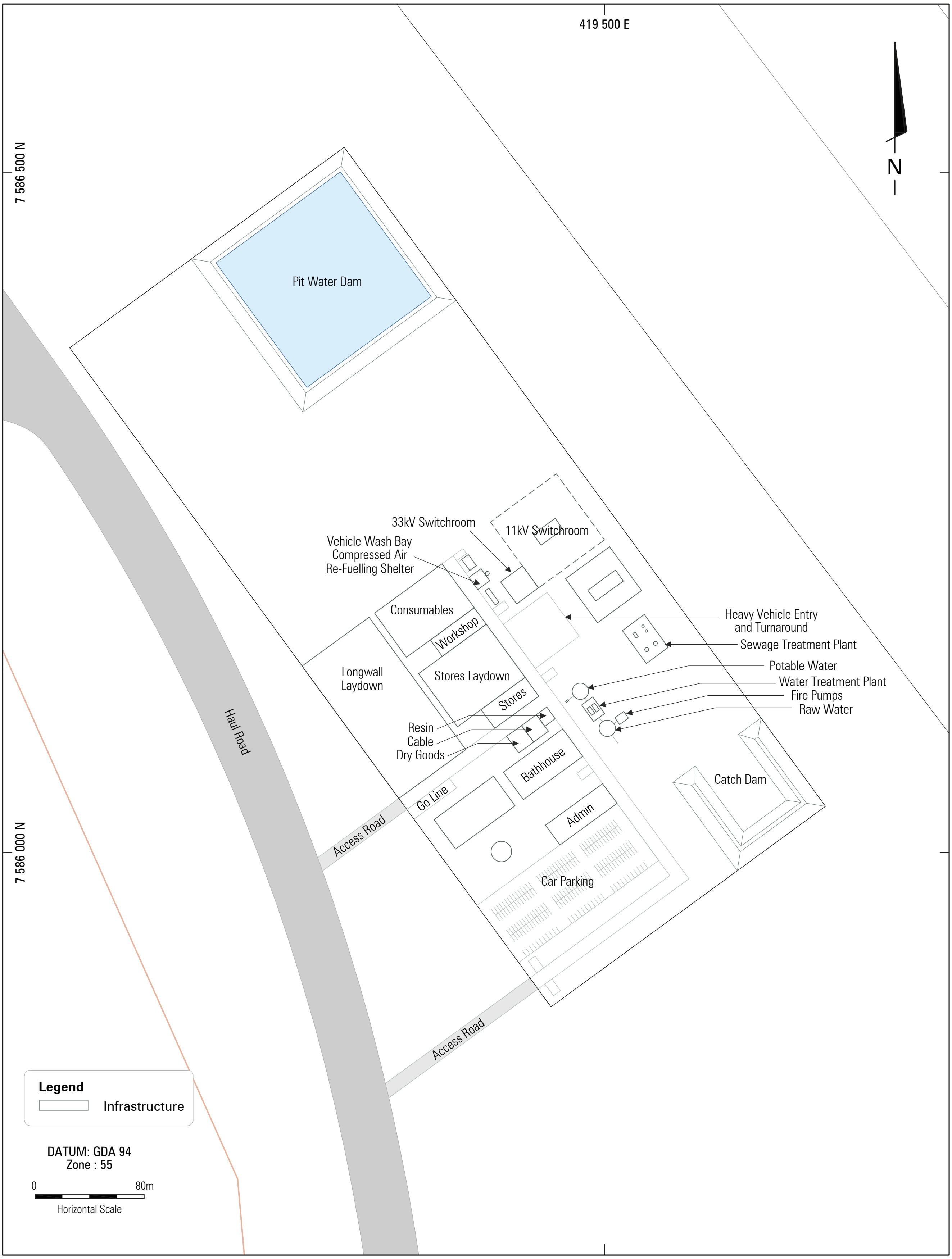
Project Layout - Northern Underground Mine Industrial Area

FIGURE 4-25



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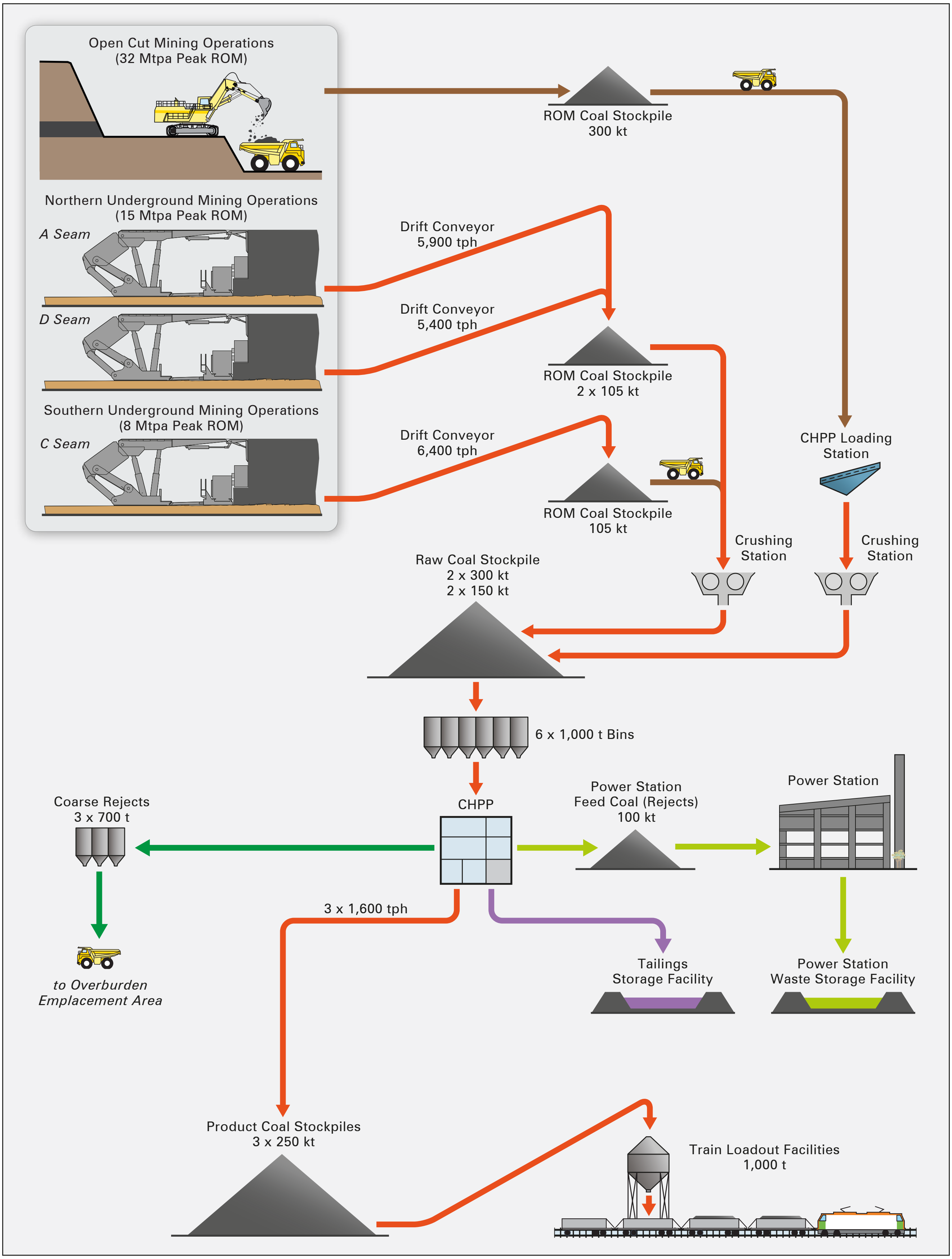
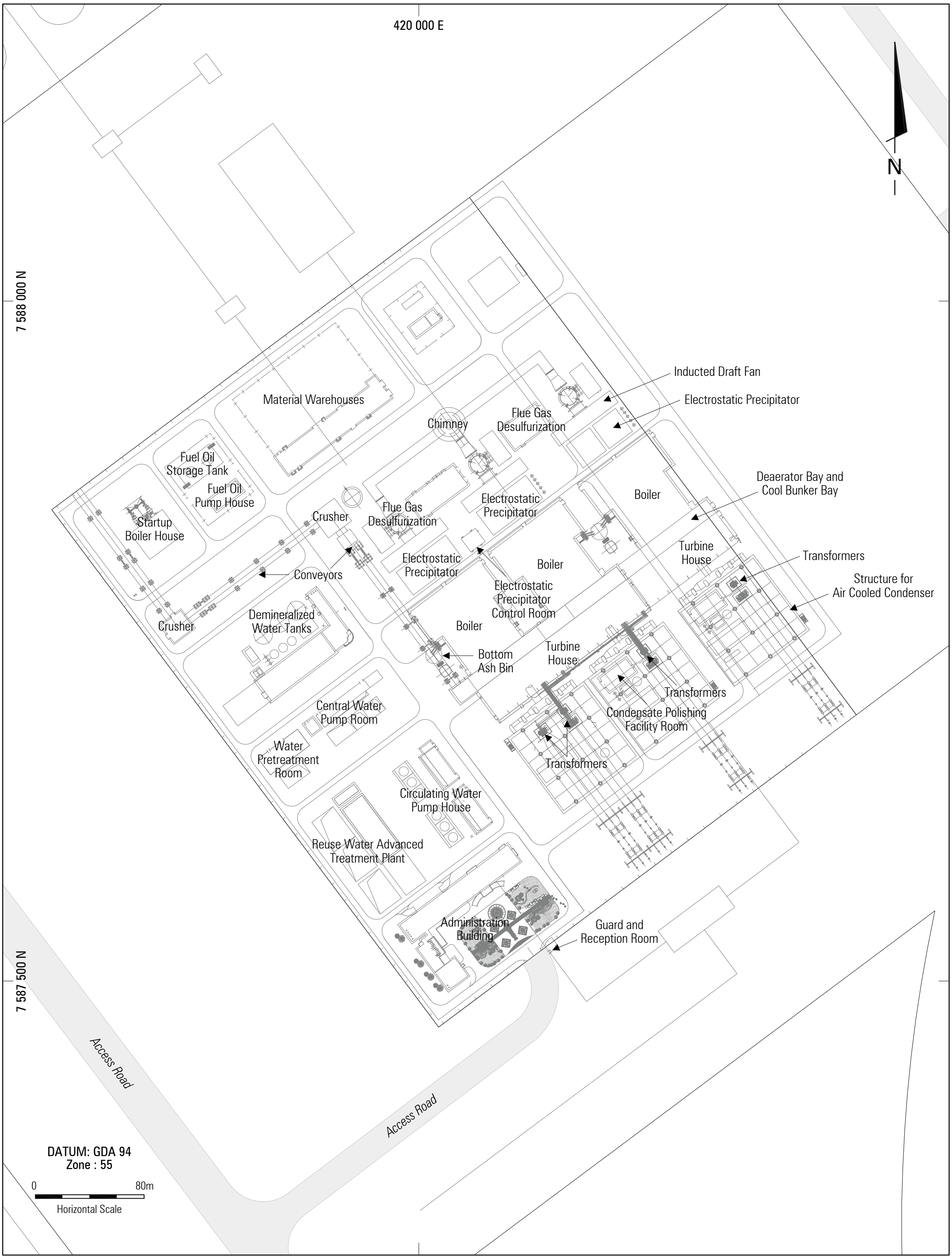
Project Layout - Southern Underground Mine Industrial Area

FIGURE 4-26



Coal Handling System
Conceptual Process Flowsheet

FIGURE 4-27



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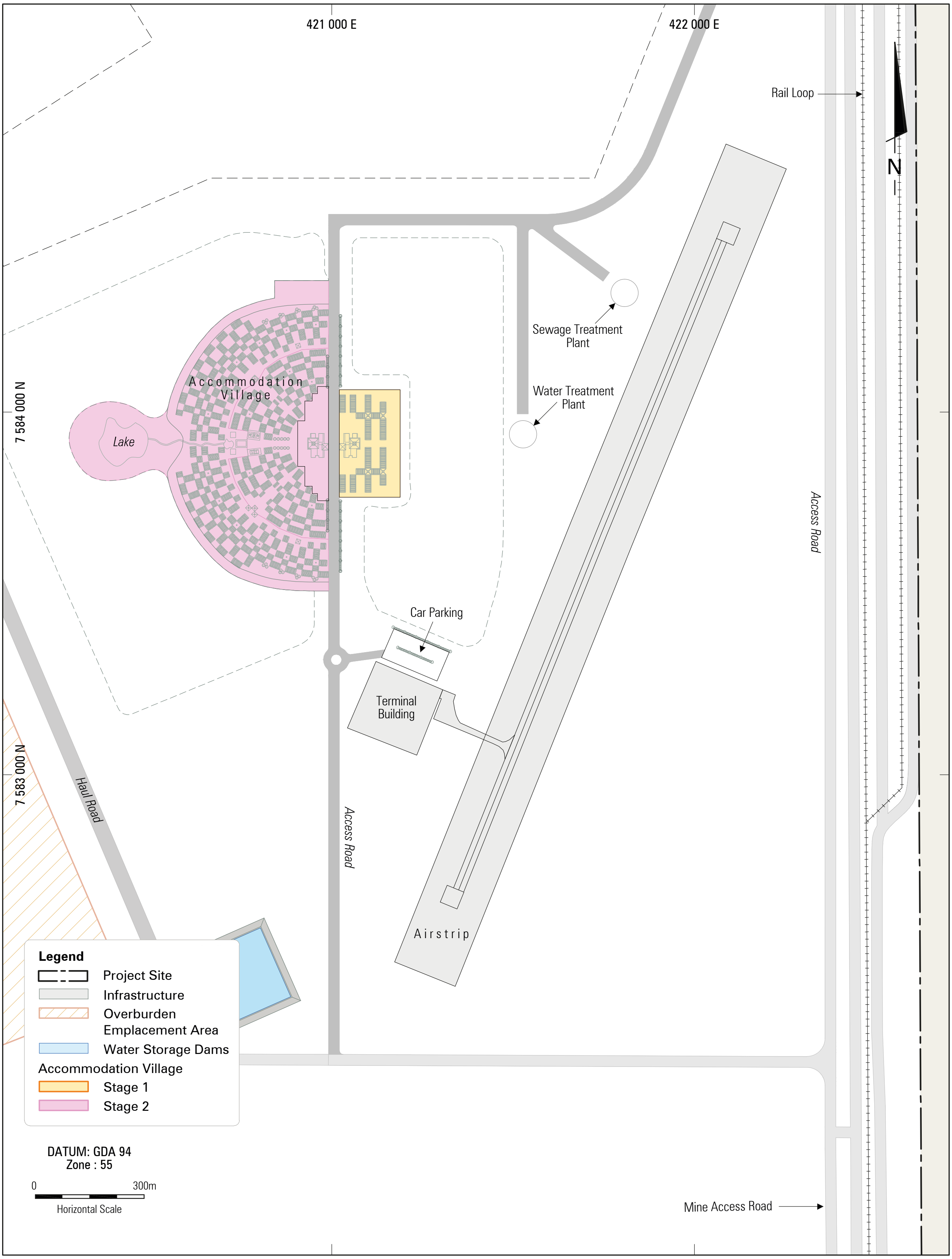
Project Layout - Power Station Detail

FIGURE 4-28



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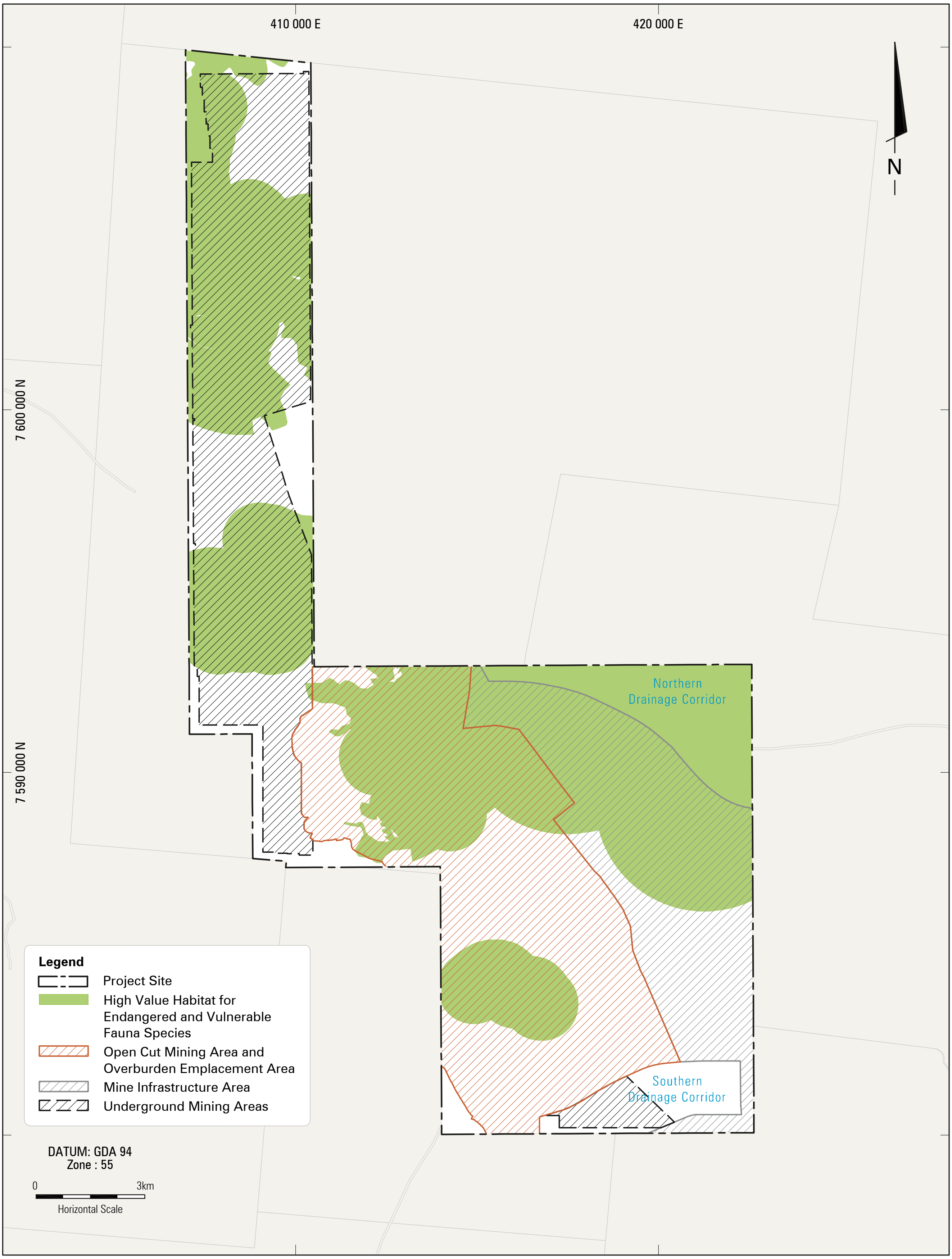
Project Layout -
Accommodation Village and Airstrip Detail

FIGURE 4-29



PROJECT CHINA STONE

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Habitat Disturbance

FIGURE 4-30

PROJECT CHINA STONE

Subsidence Report

A

GORDON GEOTECHNIQUES

GORDON GEOTECHNIQUES PTY LTD
ACN 127 420 839

SUBSIDENCE PREDICTION REPORT FOR PROJECT CHINA STONE

Prepared for Hansen Bailey
On behalf of MacMines Austasia Pty Ltd

OCTOBER 2014

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List of Abbreviations

ASL - Above Sea Level
GGPL - Gordon Geotechniques Pty Ltd
LIDAR - Light Detection and Ranging or Laser Imaging, Detection and Ranging
LOMS - Limit of Measurable Subsidence

Mtpa - Million Tonnes per Annum
ROM - Run of Mine
SDPS - Surface Deformation Prediction System
S_{max} - Maximum Subsidence

1 INTRODUCTION

1.1 Background

Gordon Geotechniques Pty Ltd (GGPL) was commissioned by Hansen Bailey on behalf of MacMines Austasia Pty Ltd (the proponent) to complete a subsidence assessment as part of the Environmental Impact Statement (EIS) for Project China Stone (the project).

1.2 Project Description

The project involves the construction and operation of a large-scale coal mine on a greenfield site in Central Queensland. The project site (the area that will ultimately form the mining leases for the project) is remote, being located approximately 270 km south of Townsville and 300 km west of Mackay at the northern end of the Galilee Basin **(Figure 1**).

FIGURE 1

Figure 1. Project Location.

The closest townships are Charters Towers, approximately 285 km by road to the north, and Clermont, approximately 260 km by road to the south-east. The project site comprises approximately 20,000 ha of well vegetated land, with low-lying scrub in the south and east and a densely vegetated ridgeline, known as ‘Darkies Range’, running north to south through the western portion of the site.

The mine will produce up to approximately 55 million tonnes per annum (Mtpa) of Run of Mine (ROM) thermal coal. Coal will be mined using both open cut and underground mining methods (**Figure 2**). Open cut mining operations will involve multiple draglines and truck and shovel pre-stripping. Underground mining will involve up to three operating longwalls. Coal will be washed and processed on site and product coal will be transported from site by rail. It is anticipated that mine construction will commence in 2016 and the mine life will be in the order of 50 years.

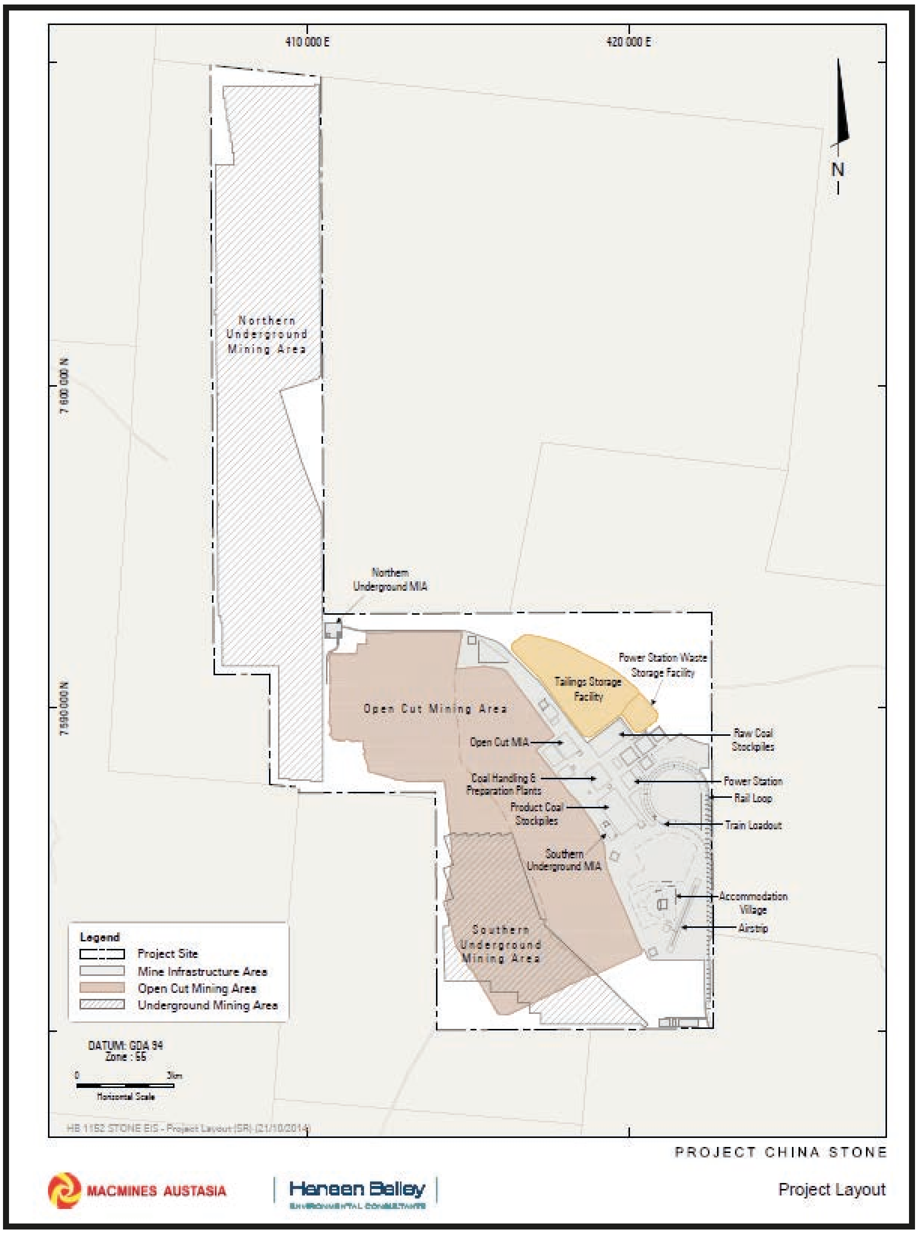

Figure 2. Project Layout.

The majority of the mine infrastructure will be located in the eastern portion of the project site (**Figure 2**). Infrastructure will include coal handling and preparation plants (CHPPs), stockpiles, conveyors, rail loop and train loading facilities, workshops, dams, tailings storage facility (TSF) and a power station. A workforce accommodation village and private airstrip will also be located in the eastern part of the project site.

1.3 Longwall Mining Method and Layout

The project involves establishing up to three longwall operations in the Northern and Southern Underground Mining Areas (**Figure 3**). The Southern Underground will carry out longwall mining in the C Seam. The majority of the Southern Underground is located beneath the open cut mine (**Figure 2**). The Northern Underground will involve longwall mining in both the A Seam and D Seam.

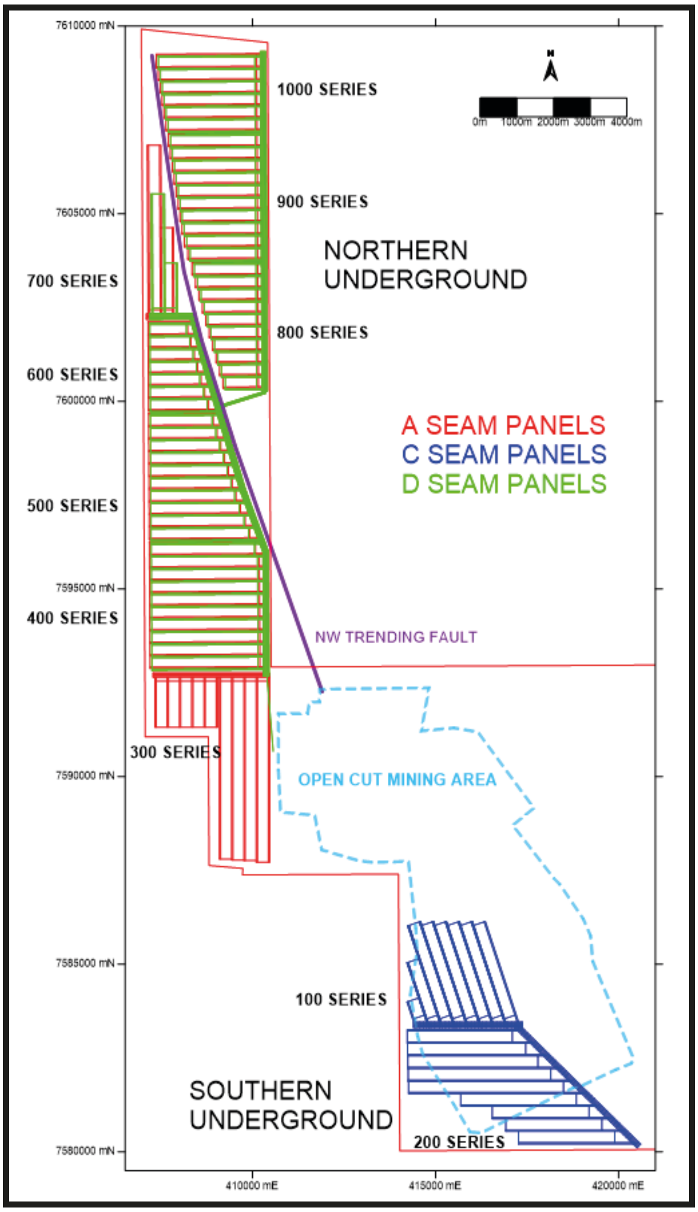

Figure 3. Underground Mine Plan.

The Northern Underground is located beneath Darkies Range in the northern section of the project site (**Figure 2 and Figure 4**).

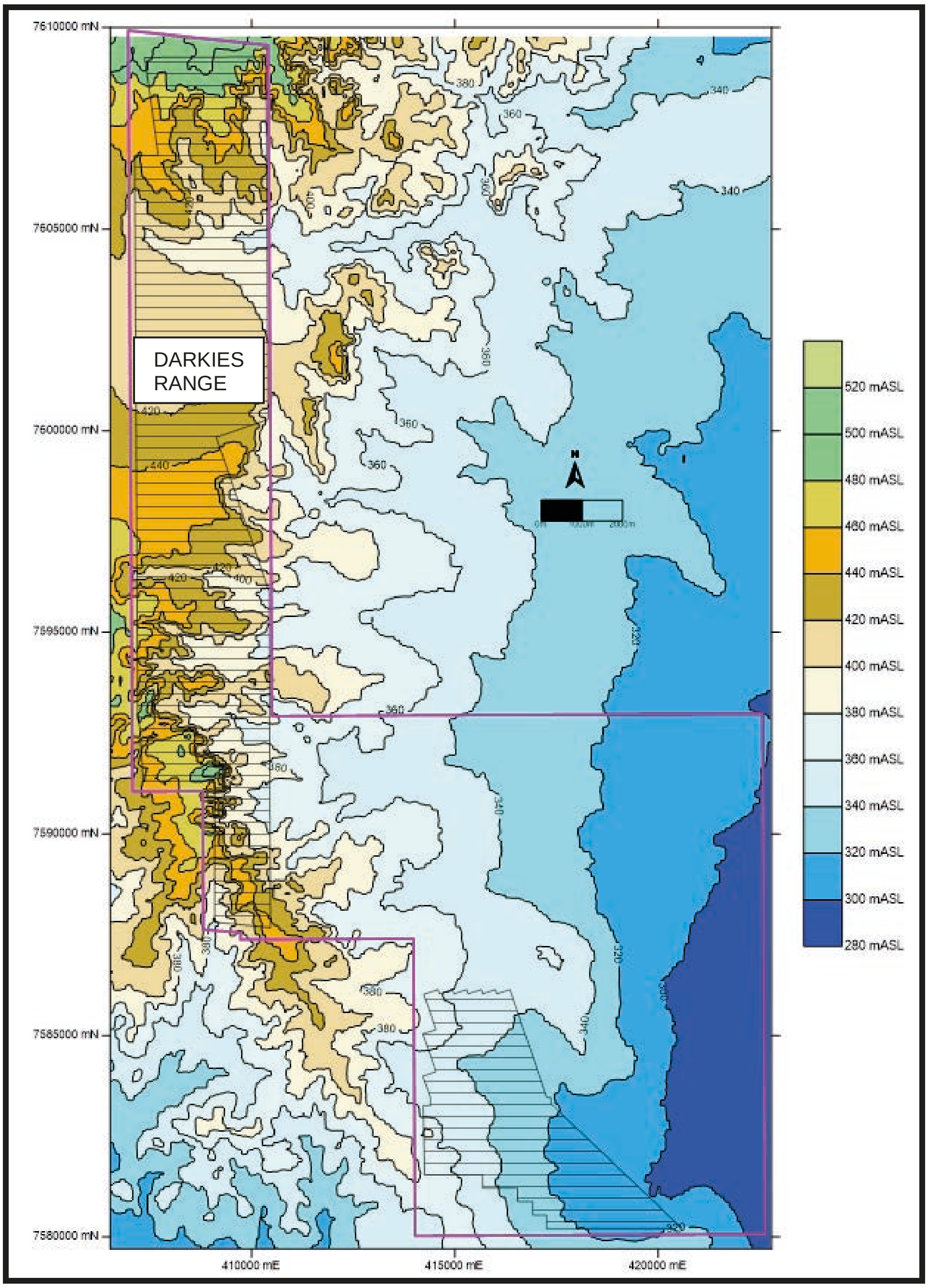

Figure 4. Surface Contours (m ASL).

The layout of the A and D Seam longwall mines is constrained by the proposed lease boundary, as well as the NW trending geological fault that has been interpreted through the northern part of the Northern Underground area (**Figure 3**). The mine schedule indicates that the underlying D Seam will be extracted prior to the A Seam.

Seventeen longwalls panels are also planned in the C Seam longwall mine in the Southern Underground. The northern 100 Series C Seam panels are planned to be extracted before the overlying seams are removed by the open cut operation (**Figure 3**).

Longwalling in the D Seam is planned to finish approximately 27 years after underground roadway development starts. The mining schedule indicates an approximate time lag of 10-15 years between mining in the lower D Seam panels and extraction of the overlying A Seam panels, allowing 5 to 10 years for consolidation of the underlying goaf.

The longwall panels in the A, C and D Seams are designed at 300 m wide (centre dimension) with two heading gateroads (**Figure 3**). Chain pillar widths are 35 m (centre dimension), irrespective of the depth of cover.

1.4 Scope of Work

This assessment includes the development of subsidence predictions and an assessment of subsidence effects for the proposed longwall mining operations in the Northern and Southern Undergrounds (**Figure 2**). The specific scope of work included:

- A four day site visit to inspect the surface area to be subsided and identify any surface features potentially sensitive to subsidence effects.
- Description of the site geology and mine plan as they relate to subsidence predictions.
- Detailed description and justification of the subsidence prediction methodology and any associated limitations.
- Subsidence modelling using the influence functions methods as implemented in the SDPS subsidence program[1] to visualize the resulting subsidence bowl of the longwall extraction and produce surface subsidence contours.
- Description of the predicted subsidence effects including:
  - The magnitude and nature of the subsidence predictions including vertical subsidence, strains and tilts.
  - The nature and extent of predicted surface cracking (range and maximum surface width and depth).
  - The nature and extent of subsurface strata cracking (height of continuous and discontinuous cracking above the mine workings), including comparisons with experience from other similar longwall mines.
  - Potential for hydraulic connectivity to the surface due to subsurface cracking.
  - Potential effects on surface geological features including subsidence and cracking.

1.5 Report Structure

Section 1 of this report introduces the project, including the proposed longwall mining layout and geology of the project site.

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[1] www.carlsonsw.com

Section 2 details the geology, stratigraphy, depth of cover and coal seam and interburden thickness.

Sections 3, 4 and 5 describe subsidence methodology, predictions and potential subsidence effects from the project, respectively.

2 ENGINEERING GEOLOGY

2.1 Geological Data

The proposed longwall mining area is covered by closely spaced exploration drilling, as shown in **Figure 5**. These surface drill holes record the geological sequence of the overburden and coal seams.

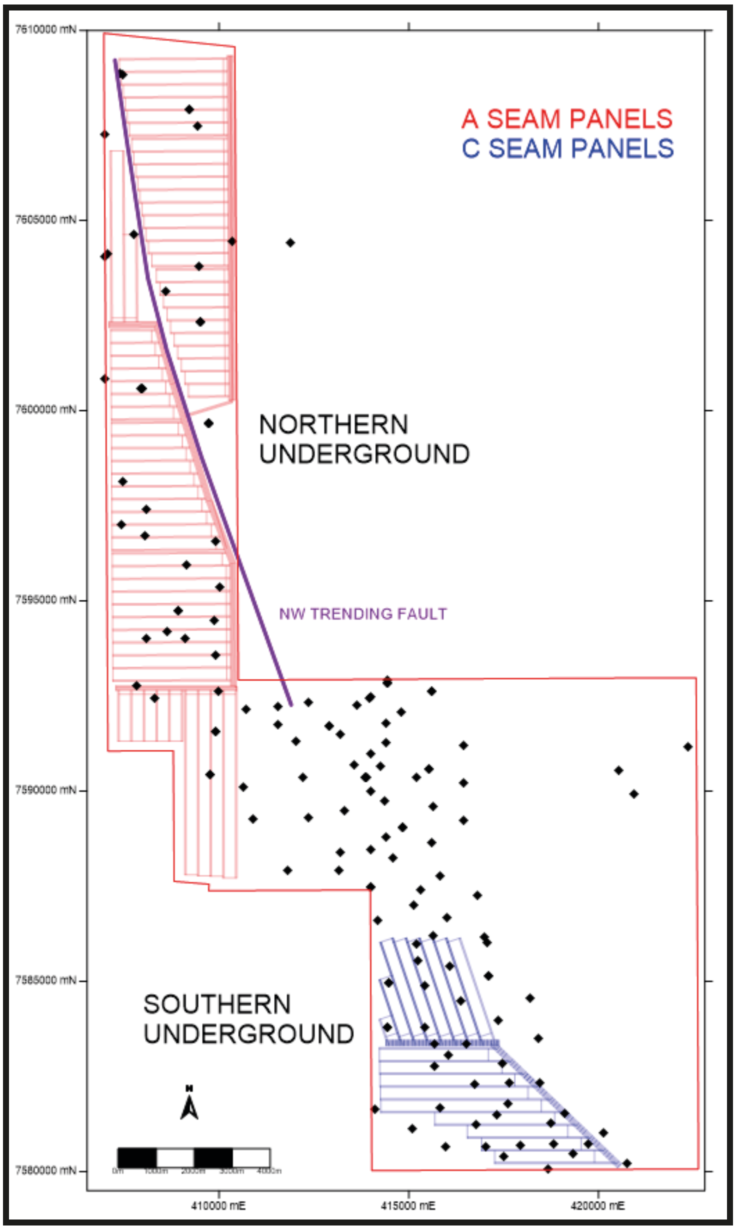

Figure 5. Borehole Location Plan.

In the majority of drill holes, geophysical logs are also available and provide additional data on the rock and coal seam properties. This density of data provides a high level of confidence in the geological variables used as input into the subsidence models in the proposed mining areas.

2.2 Stratigraphy

In the project site, the coal seams are part of the Betts Creek Beds (**Figure 6**). The target seams for longwall mining are the A, C and D Seams. The sediments between the target coal seams typically consist of interbedded sandstones, siltstones and mudstones and minor coal seams.

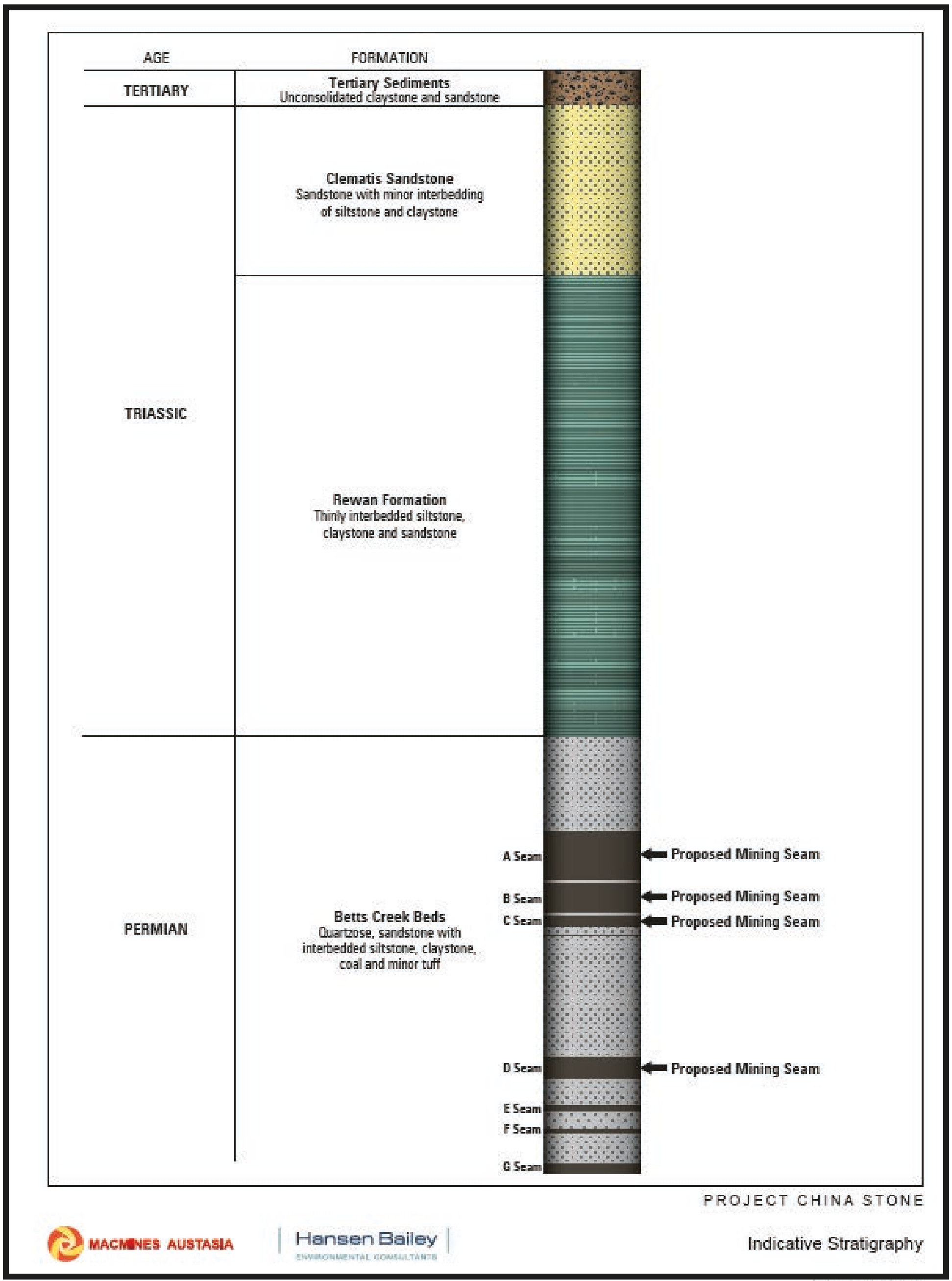

FIGURE 6

Figure 6. Indicative Stratigraphy.

2.3 Depth of Cover

The depth of cover above the proposed D Seam longwall mine, located at the base of the stratigraphic sequence, ranges from 200 m above Longwall D406, to a maximum of 490 m in the northern part of the mine above the 1000 Series longwall panels (**Figure 7**).

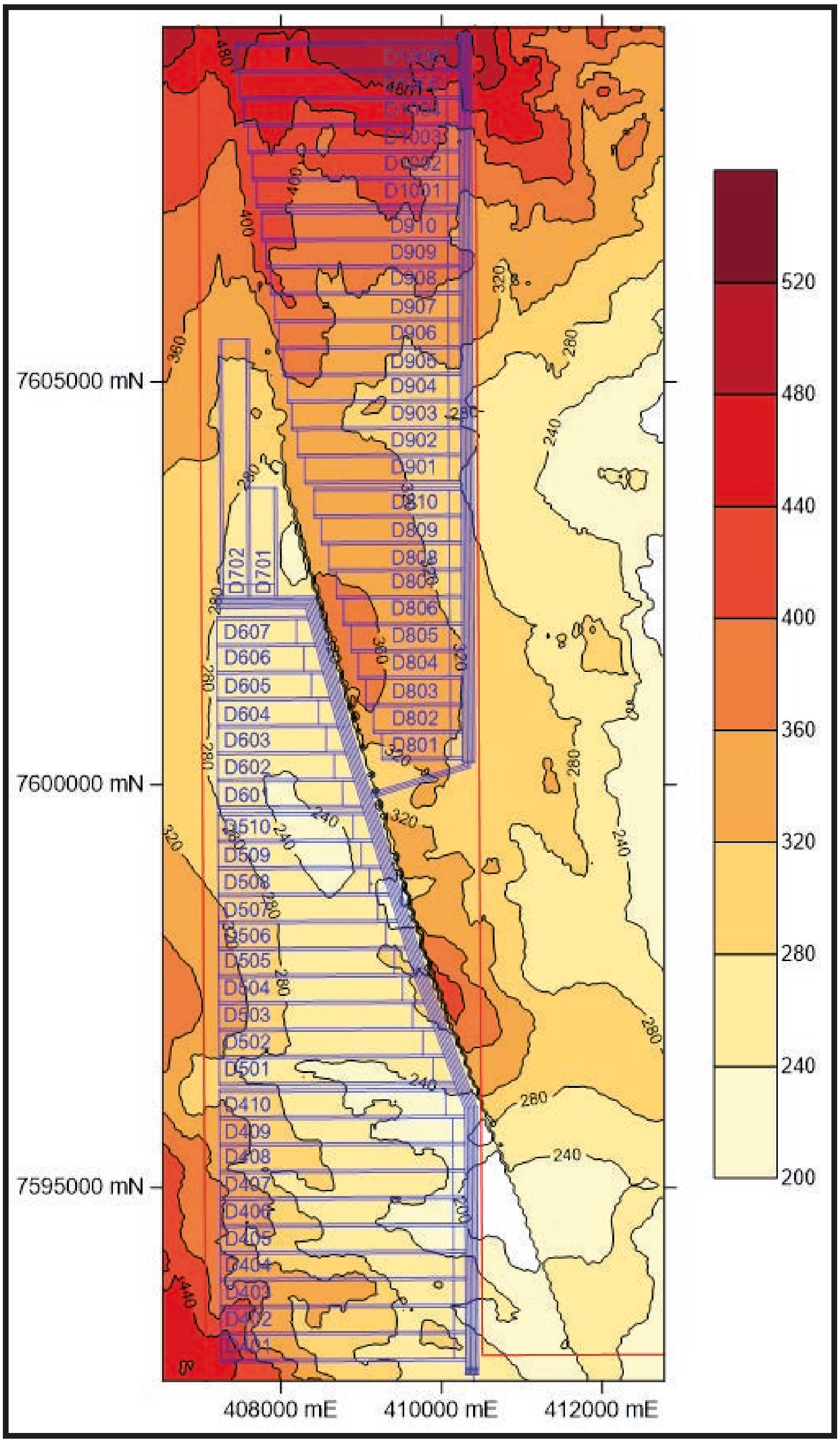

Figure 7. D Seam Depth of Cover (m).

The interburden between the A and D Seams is generally 50-70 m thick in the proposed mining area indicating that the A Seam longwall panels are located at depths of 140 m up to 420 m.

The C Seam longwall extraction ranges in depth from <100 m in the eastern part of the mine, to up to 450 m at the western end of Longwall C205 in the western part of the project site (**Figure 8**).

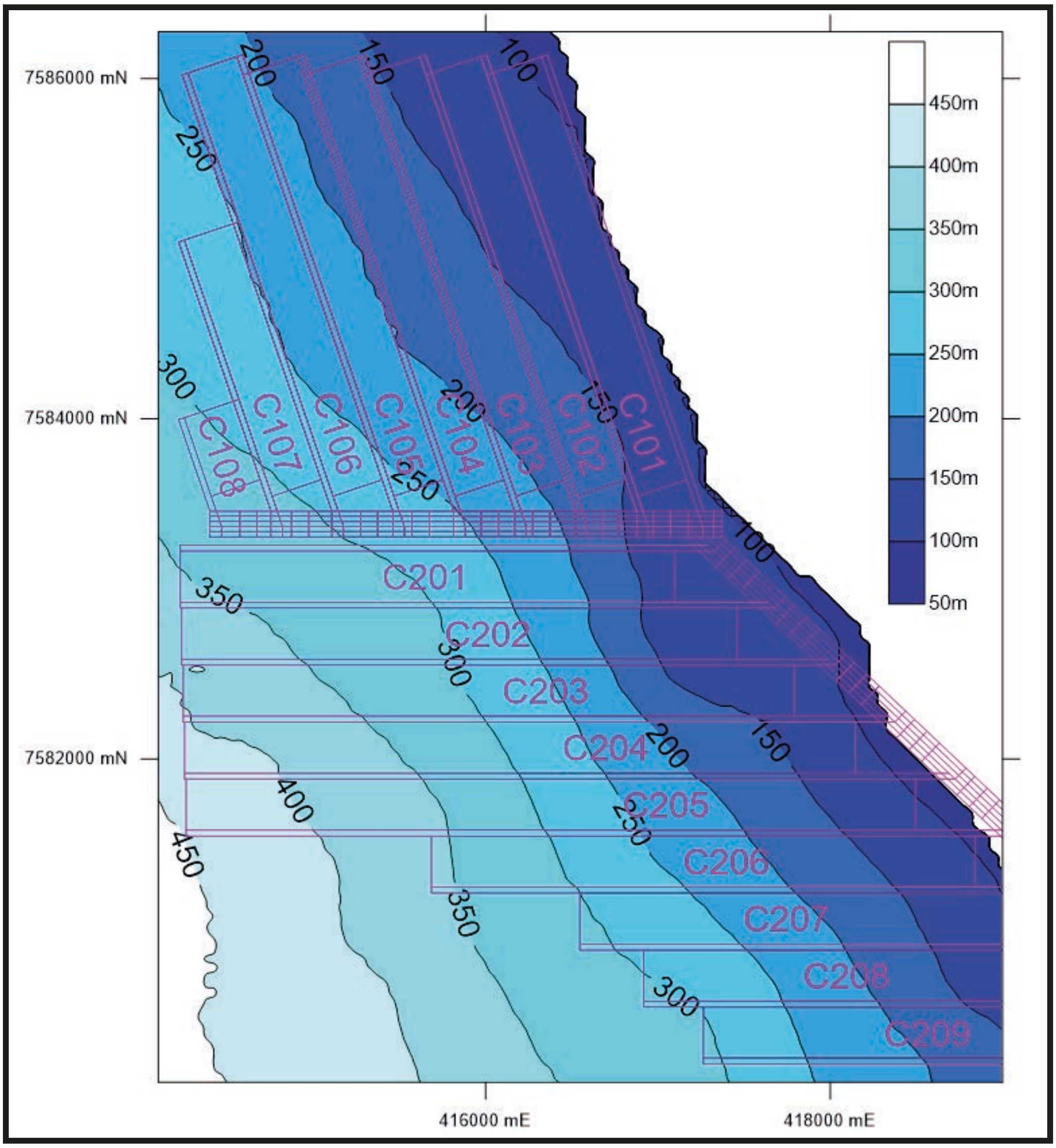

Figure 8. C Seam Depth of Cover (m).

2.4 Seam Thickness

The planned extraction height in the A and C Seams is 4.5 m. For the D Seam, due to the decrease in thickness from north to south, a progressive reduction in extraction height from 4.5 m to 3 m is planned. These extraction heights have been used in the subsidence models presented in section 4 of this report.

2.5 Floor Levels

The influence of the NW trending fault through the Northern Underground is clearly shown in **Figure 9**. This geological feature is downthrown by approximately 100 m towards the east.

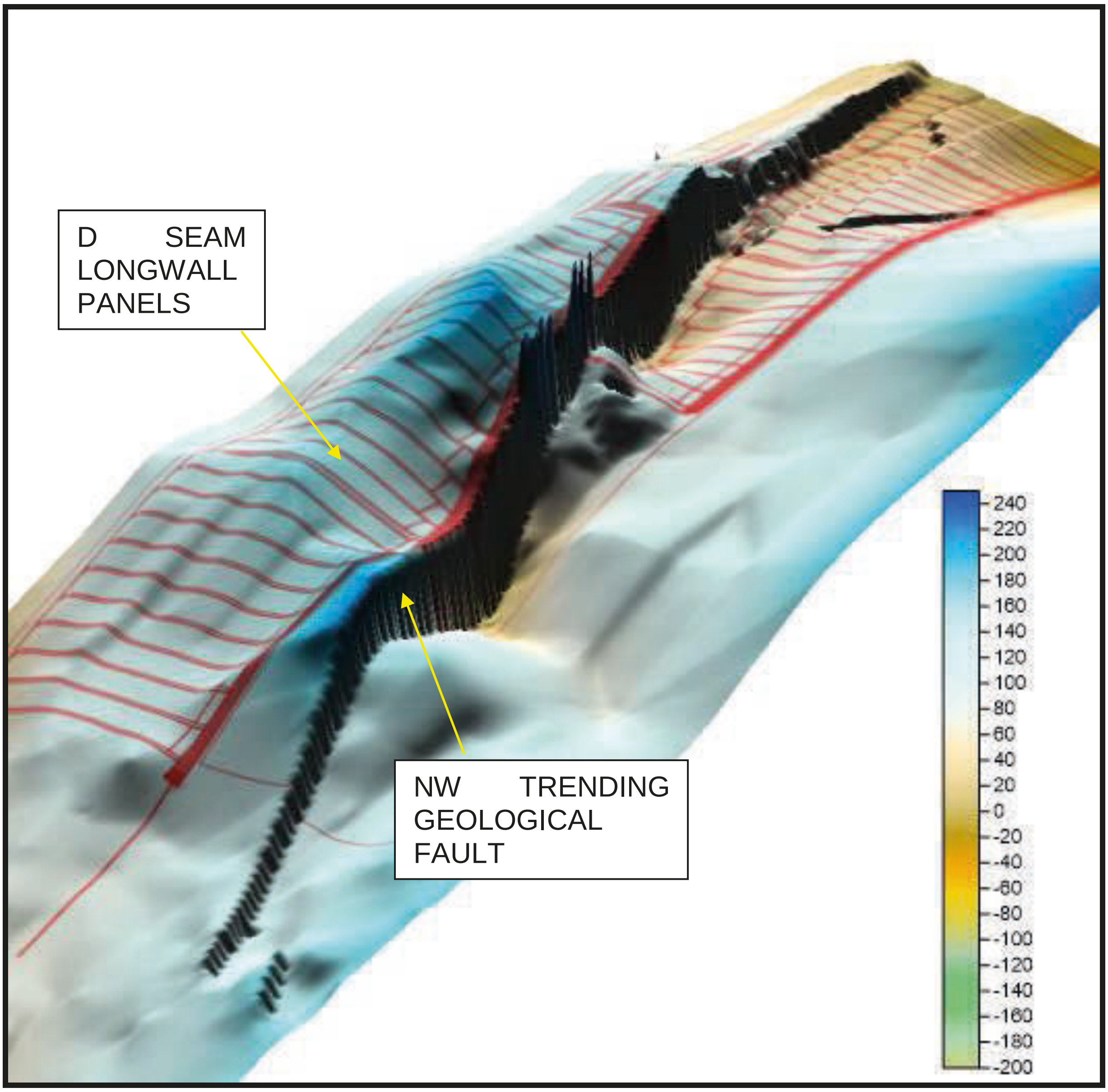

Figure 9. 3D Surface of the D Seam Structure Floor Levels (mASL).

3 SUBSIDENCE PREDICTION METHODOLOGY

3.1 Introduction to Surface Deformation Prediction System (SDPS)

GGPL has used the SDPS software to visualise the subsidence deformations in the project longwall mining areas. The SDPS program uses an influence function method that assumes the shape of a subsided surface can be modelled with a Gaussian (bell shaped) curve. This technique is a proven and reliable prediction methodology widely used throughout QLD and NSW, for EIS assessments and predictions of subsidence effects due to longwall mining beneath structures such as dams, highways and transmission towers[2].

The method requires calibration to existing survey data and mine geometry. The following inputs are required:

- Panel Layouts (corrected by the adjustment factor)
- Seam Thickness
- Depth of Cover
- Angle of Influence
- Subsidence Factor (maximum subsidence (S_{max})/extracted thickness ratio)
- Strain Coefficient

It should be noted that the SDPS methodology can only predict overall or systematic deformations. All subsidence surveys reveal small scale variations from the smooth profile predicted by this method. These deformations can be related to localised movements of blocky rock that is a feature of all coal mine overburdens.

Published dual seam longwall experience has also been referenced from the Australian and overseas coal mining industry.

Based on subsidence data from the neighbouring Bowen Basin presented in the South Galilee EIS (2012)[3], the following parameters were used for modelling in the proposed longwall mining areas:

- Panel Adjustment Factor of 0.2.
- Influence Angle of 77^o to maximise the tilts.
- Maximum Subsidence Factor of 60% for extraction in virgin ground and 75% for A Seam extraction above D Seam goaf areas.
- Strain Coefficient of 0.2.

These parameters are consistent with those used by GGPL at Bowen Basin mines for non-published subsidence studies. Similarities in the geology of the Bowen and Galilee Basins also justifies the application of these parameters to the project longwall mining areas. The coal bearing sequence in the project area was deposited at the same time geologically (late Permian) as the Bowen Basin coal measures.

---

[2] Byrnes R. 2003. Case studies in the application of influence functions to visualising surface subsidence. COAL2003 - 4th Underground Coal Operators Conference. AusIMM Illawarra Branch.

[3] South Galilee EIS (2012). Life of Mine Subsidence Deformations.

The overlying Rewan Formation in the project area, also occurs in the overburden of underground longwall mines such as Kenmare and Cook in the Blackwater area of the Bowen Basin and Newlands in the northern part of the basin.

Discussion of how these parameters were developed is included in the following sections. It should be highlighted that chain pillar deformations have not been analysed, resulting in a more conservative approach whereby the resulting strains and tilts are higher. This is due to the calculation of the subsidence above the chain pillars as simply the arithmetic sum of the subsidence developed above adjacent "isolated" panels.

3.2 Subsidence Behaviour

The subsidence above longwall panels is comprised of two main components namely sag subsidence and strata compression. Depending on the depth of cover and width of extraction these components combine in various proportions (**Figure 10**).

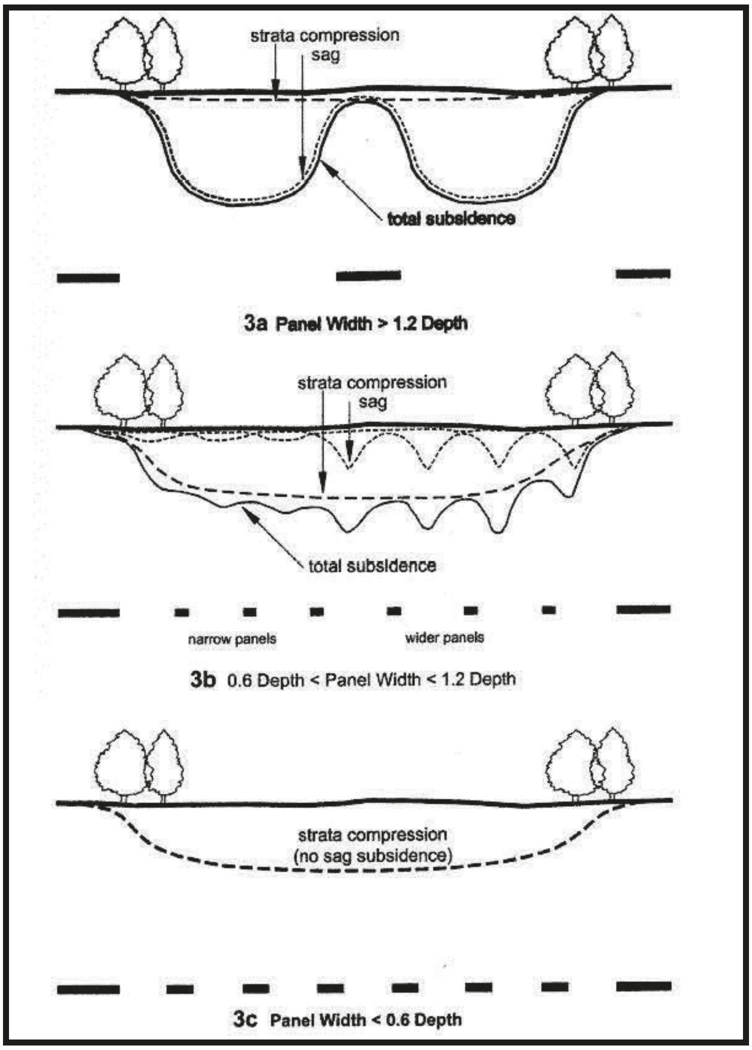

Figure 10. Effect of Panel Width (AusIMM, 2009[4]).

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[4] AusIMM (2009). Australasian Coal Mining Practice – Monograph Series 12. Pp1085.

At the planned depths and panel widths in the proposed mining areas, the sag subsidence is expected to be a large component of the total subsidence in the majority of the proposed longwall mining areas (**Figure 10**). This is termed supercritical subsidence. In these areas, the maximum vertical subsidence does not increase as the panel width increases.

In the deeper longwall mining areas at the project site, where the panel width/depth ratio is <1.2, strata compression will contribute a higher component of the total subsidence (**Figure 10**).

Due to the extraction of the A Seam longwall panels above the D Seam longwall

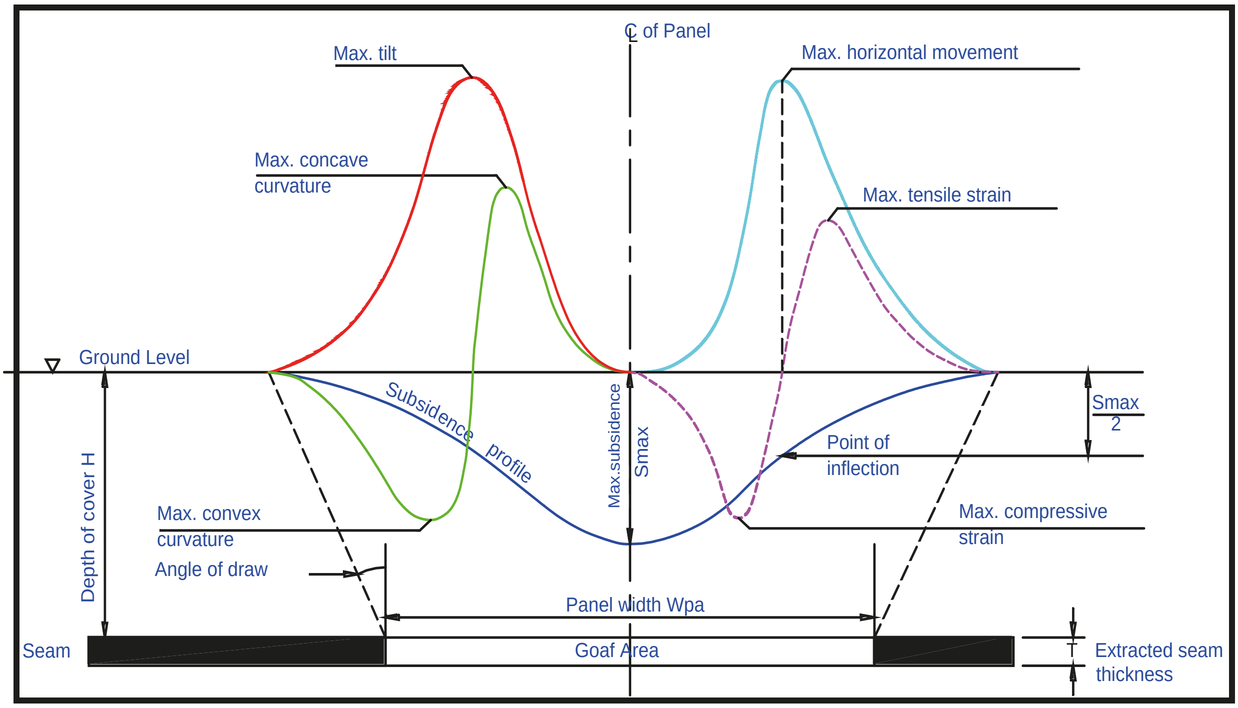

Figure 11. General Characterisation of a Subsidence Cross Line.

- The areal extent of subsidence is defined by the angle of draw. Conventionally the angle of draw is measured from the point of 20 mm of vertical subsidence (not zero), which equates to the limit of measurable subsidence (LOMS). Subsidence less than 20 mm will have a negligible effect, as it cannot be differentiated from natural ground surface variations due to soil moisture changes.
- Maximum tilt should correspond with zero strain.
- The subsidence at the point of maximum tilt and zero strain should be ½ the maximum vertical movement.

- The maximum tilts or strains do not necessarily correspond with the edge of the extraction.

These parameters characterise the surface deformations above the extracted longwall panels and provide context to the resulting impacts.

3.3 Determination of Subsidence Factors

3.3.1 Single Seam

A subsidence factor ratio of maximum subsidence (S_{max}) to extracted thickness (T) in virgin ground has been estimated from Bowen Basin data and empirical data from NSW (**Figure 12**). This ratio is the percentage of the extracted thickness underground, measured as subsidence on the surface. It should be highlighted that an empirical curve has not been developed for the Bowen Basin due to fact that the majority of the extraction has been carried out at panel width:depth of cover ratios >0.8 (**Figure 12**).

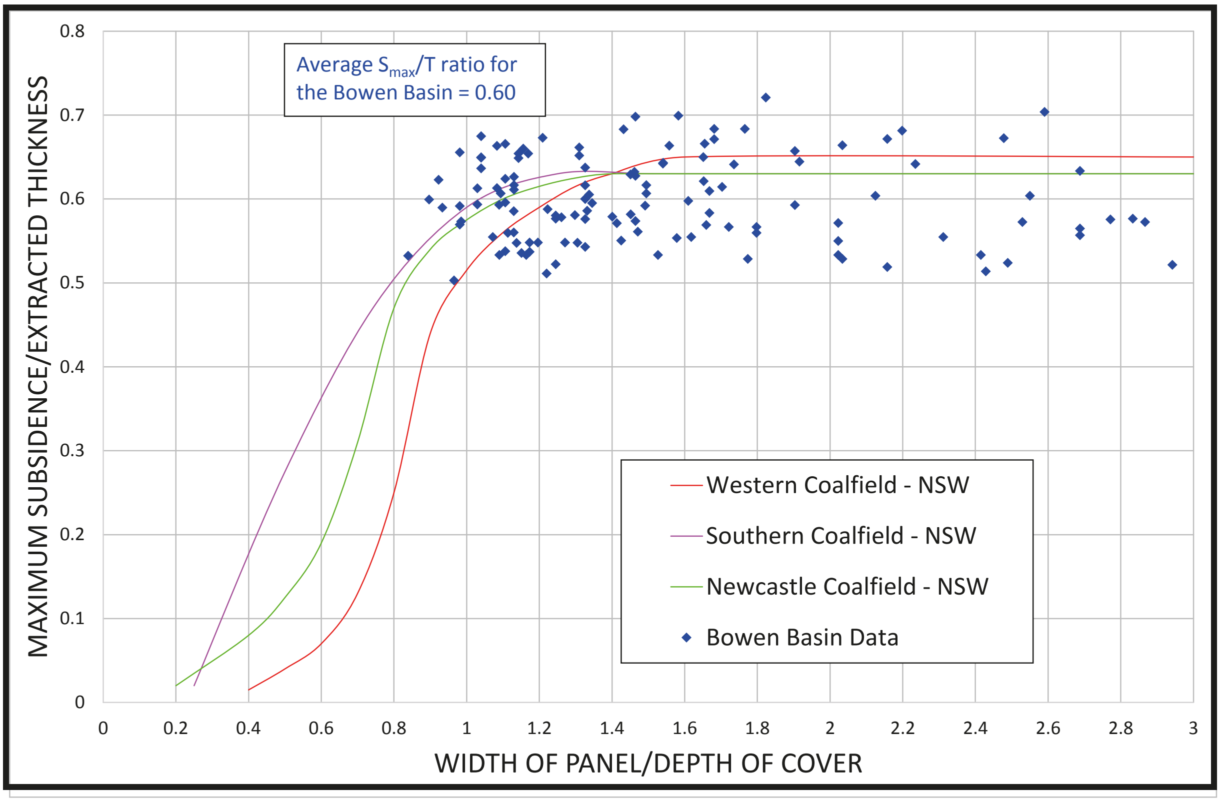

Figure 12. Empirical Curves for Sag Subsidence over Single Panels in Virgin Ground.

Available Bowen Basin data validates the application of a 60% subsidence factor to the project longwall area for extraction in virgin ground (**Figure 12**). In localised parts of the proposed mining area, the ratio of the panel width:depth ratio is less than 1. In these areas the subsidence factor has been correspondingly reduced in SDPS, based on the empirical subsidence curves presented in **Figure 12**.

3.3.2 Dual Seam

Li et al (2010), have recently reported experience in dual seam longwall extraction[5]. In their case study, subsidence data for over-mining at Cumnock and North Wambo mines was presented.

At these mines the upper seams are located 43 m and 180 m, respectively, above the lower seams which were extracted first. The A Seam in the project site is typically 50-70 m above the D Seam and hence is located between these two data sets.

The subsidence factor at Cumnock is 78% of the extraction height for the upper seam, compared to 67% at North Wambo (**Table 1**).

Mine	Seam	Seam Thickness (m)	Depth (m)	S_{max} (m)	Subsidence Factor (Lower Seam)	Subsidence Factor (Upper Seam)	Subsidence Factor (Both Seams)
Cumnock	Upper	2.2	90	1.72		78%	
	Lower	2.5	133	1.25	50%		
	Both	4.7		2.97			63%
Wambo	Upper	2.6	80	1.74		67%	
	Lower	3.3	260	1.57	48%		
	Both	5.9		3.31			56%

Table 1. Subsidence Parameters from Cumnock and Wambo (Li et al, 2010).

Based on this data, a conservative maximum 75% subsidence factor has been applied to the A Seam extraction located in the fractured zone of the D Seam extraction (**Figure 13**). In areas of lower ratio panel width to depth of cover, the subsidence factor was correspondingly reduced in line with empirical data.

MSEC (2007)[6] also proposed that the additional ground movement in a dual seam mining environment is dependent upon the thickness of the interburden between the seams, as well as the thickness of the seams to be extracted.

In the case of the combined A and D Seam extraction, the total subsidence at any point is a simple addition of individual values for each seam. The same is not true of the strain and tilts. SDPS has the facility to allow models to be run with both seam layouts simultaneously, to provide outputs of these parameters. This methodology has been utilised in areas where both the A and D Seams are extracted.

---

[5] Li, G., Steuart, Paquet, R., and Ramage, R (2010). A case study on mine subsidence due to multi-seam longwall extraction. 2nd Australasian Ground Control in Mining Conference. Pp. 191-200.

[6] Mine Subsidence Engineering Consultants (2007). General discussion on systematic and non systematic mine subsidence ground movements. Revision A, August 2007.

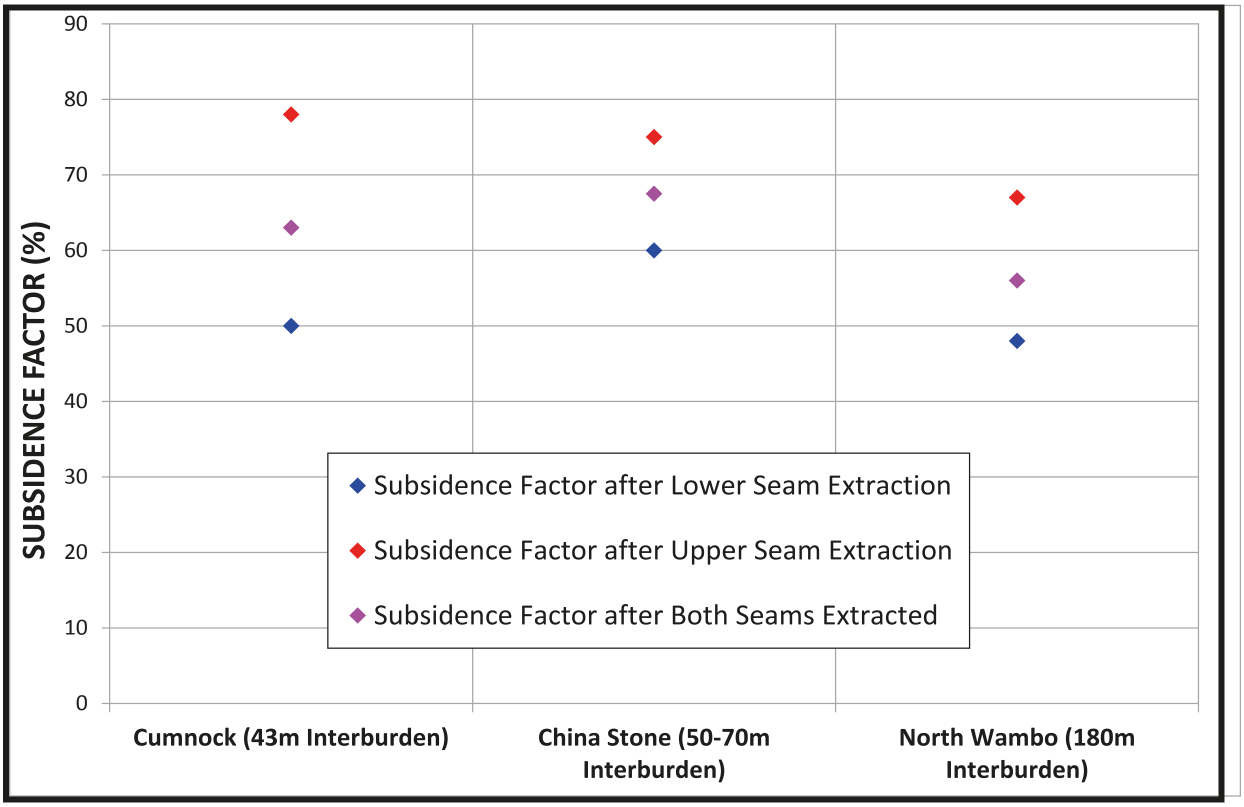

Figure 13. Subsidence Factors for Dual Seam Extraction.

3.4 Determination of the Influence Angle

Using subsidence data from the Bowen Basin presented in the South Galilee EIS (2012), a high influence angle of 77^o was used in the modelling. For the A Seam, it is likely that the rock mass may be broken due to extraction of the underlying D Seam and not able to span, resulting in high influence angle values. Whilst the influence angle for the D Seam may be less than the 77^o assumption, this value is considered conservative for the purpose of the EIS. In the absence of dual seam subsidence data, the 77^o is considered appropriate to apply to extraction in the A Seam, as well as the C and D Seams.

3.5 Determination of the Panel Adjustment Factor

SDPS considers each extraction panel not by the mining edge but by the projection of the points of inflexion. The compensation width is the distance from the rib edge to the inflexion point or point of half-maximum subsidence. For wide extraction panels, the position of the inflexion points is a linear proportion of the depth of cover.

The panel adjustment factor is the compensation width divided by the depth of cover, where the compensation width is the distance measured from the rib edge to the inflection point or point of half maximum subsidence (**Figure 11**).

An average value of 0.2 was determined for the panel adjustment factor from the available published Bowen Basin data (South Galilee EIS, 2012). For the SDPS analysis of the C Seam mine, the original and compensated longwall panel boundaries are shown in **Figure 14**. Compensated boundaries were also determined for both the A and D Seam layouts using the same panel adjustment factor.

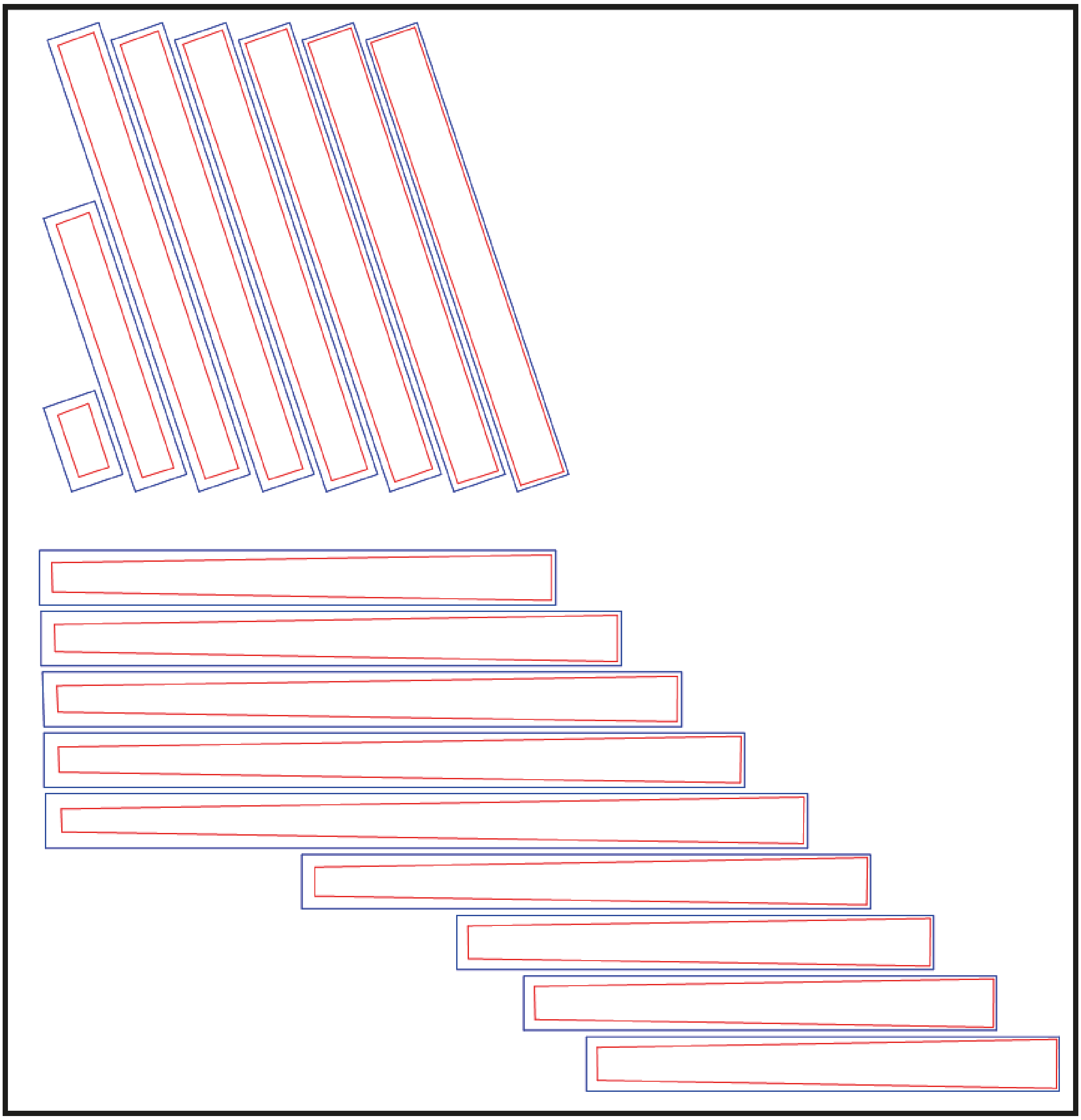

Figure 14. C Seam Longwall Mine - Original Longwall Panels (blue) and Compensated Panels (red).

3.6 Determination of the Strain Coefficient

Strain data is particularly affected by blocky rock movements and often show a large degree of dis-ordered movement. A strain coefficient of 0.2 has been used for the subsidence modelling work in the proposed longwall area, based on the Bowen Basin data presented in the South Galilee EIS (2012).

3.7 Analysis of Massive Spanning Units

For completeness, the potential for spanning massive units in both the Triassic and Permian strata above the A, C and D Seams has been assessed.

3.7.1 Permian Overburden

Conservatively assuming a 20^o caving angle, a typical rock strength of 60 MPa and a modulus of 12 GPa, a voussoir beam analysis indicates that a 49 m thick massive unit in the Permian overburden is required to span a 300 m wide longwall panel.

The variability in the gamma response of the A, C and D Seam Permian overburden in selected exploration drill holes across the longwall mining areas, indicates that any massive units are less than 30 m thick (**Figure 15, Figure 16 and Figure 17**). The potential for spanning units in the Permian overburden is therefore unlikely and it is anticipated that caving behind the retreating longwalls will occur readily.

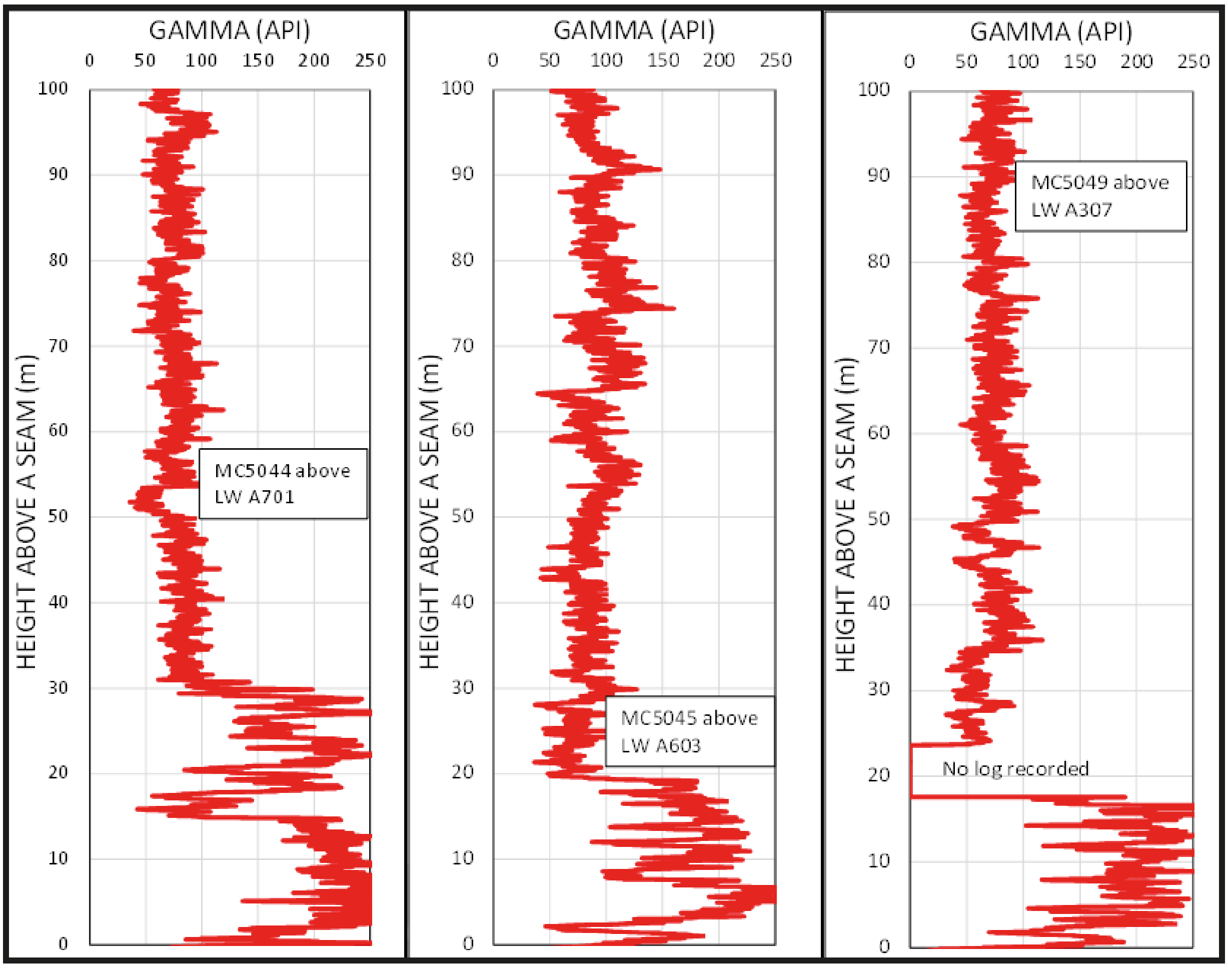

Figure 15. Gamma Response of the A Seam Overburden.

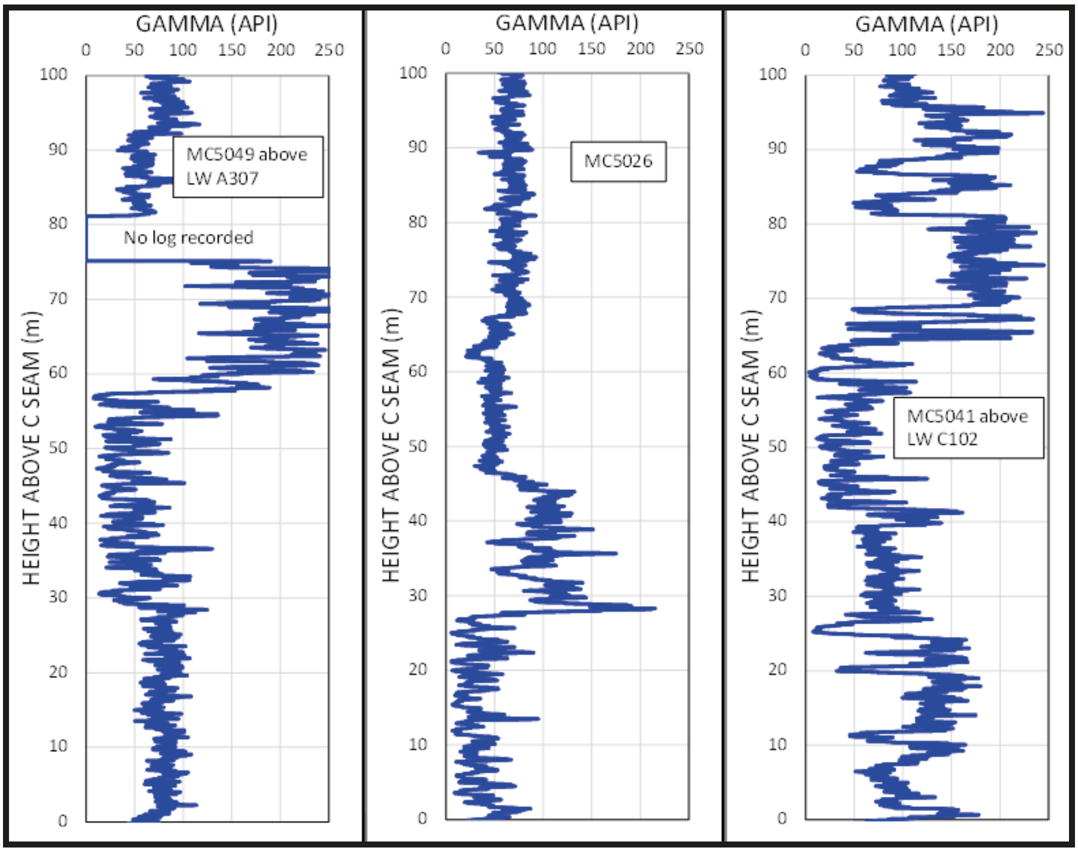

Figure 16. Gamma Response of the C Seam Overburden.

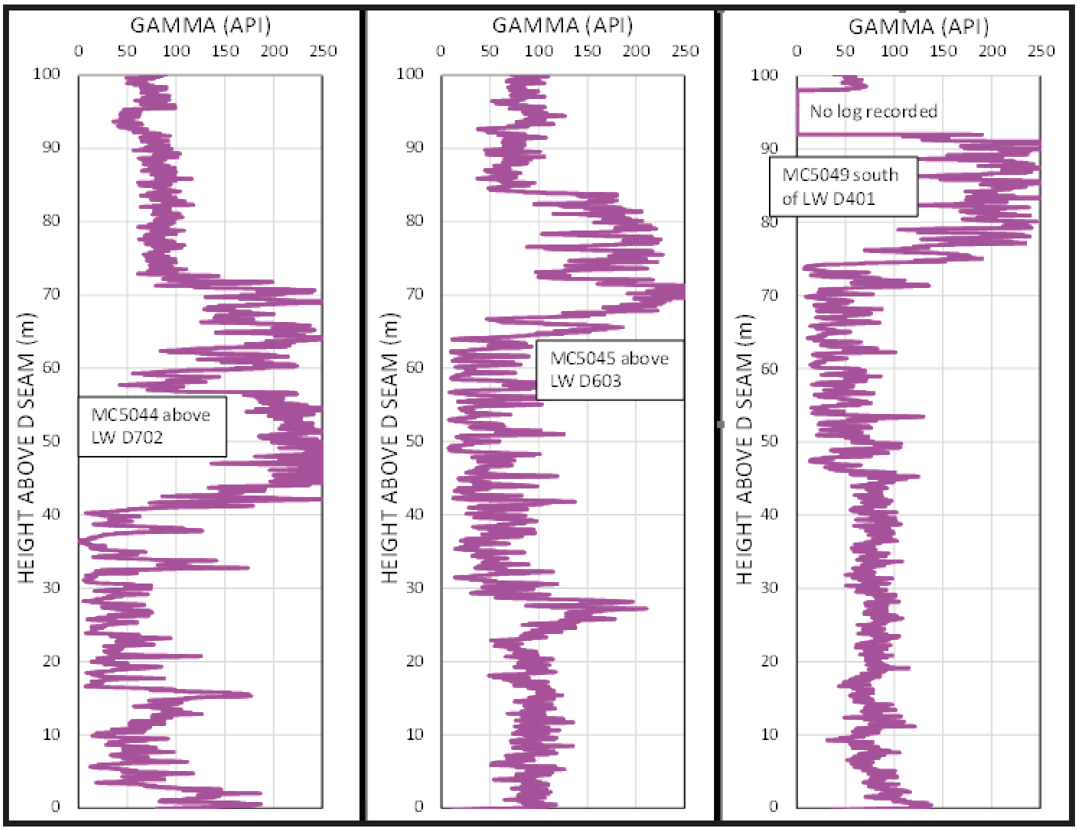

Figure 17. Gamma Response of the D Seam Overburden.

3.7.2 Triassic Clematis Sandstone

The potential for spanning of the Triassic Clematis Sandstone also needs to be assessed. The gamma logs, in conjunction with core photographs and lithological logs suggest an upper bound thickness for massive layers in this sandstone unit of 40 m.

Voussoir beam analysis of a 40 m thick Clematis Sandstone unit, located 120 m above the A Seam, indicates that as the depth increases the strength of the sandstone required to span increases to more than 100 MPa, at depths greater than 270 m (**Figure 18**). This analysis indicates that for a typical rock strength of 20 MPa this unit is not likely to be able to span a 300 m wide longwall panel.

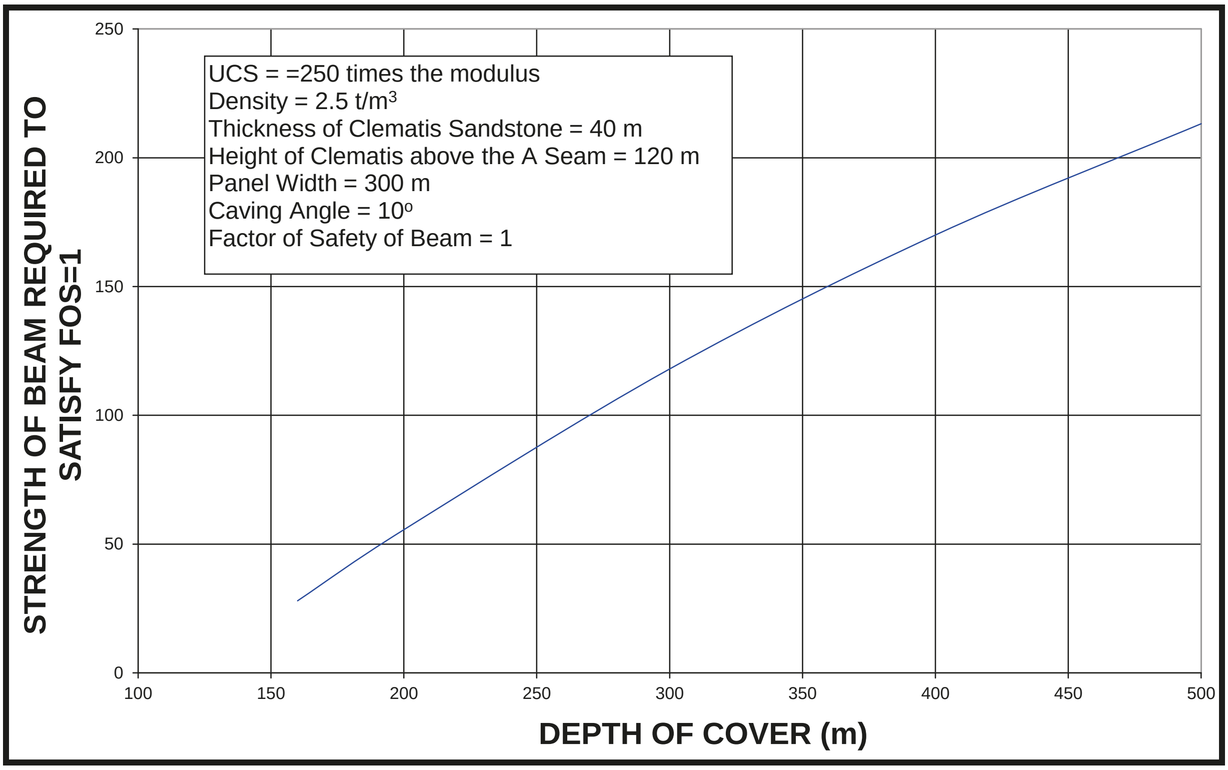

Figure 18. Sensitivity Analysis of the Strength of the Clematis Sandstone Required to Span a 300 m Wide Longwall Panel.

4 SUBSIDENCE PREDICTIONS

The results of running the SDPS models for the A, C and D Seam longwall mines are presented in the following sections. Subsidence modelling was carried out individually for both the C and D Seam and also for the combined A and D Seams.

4.1 Northern Underground

4.1.1 A and D Seam Subsidence

Predicted total subsidence from mining of the A and D Seam longwall panels is shown in **Figure 19**. Vertical subsidence reaches a maximum of 6 m in the shallower mining areas in the western part of the Northern Underground and is often >5 m. In the deeper parts of the Northern Underground, the maximum vertical subsidence reduces to 4 m. In the southern part of the area, where only the A Seam is extracted, the maximum subsidence is <2.5 m.

As well as vertical movement, minor horizontal ground movements also occur at the surface due to underground mining. These movements are more relevant if key surface infrastructure is located above the longwall extraction area. The potential horizontal displacements due to longwall mining are considered to be minor and are not considered a significant additional effect in the project area.

With the improvement in surveying techniques over the years, “far-field” effects have been measured outside the conventional 26.5^{o} angle of draw. If an elastic analysis of a rock mass is carried out, both vertical and horizontal movements of less than 20 mm are indicated outside the angle of draw consistent with the survey measurements. The horizontal movements are greater than the vertical but because of the very low magnitude of the movements, the strains are negligible. These minor horizontal movements are typically towards the extraction area (AusIMM, 2009).

These “far-field” effects do not occur below the surface and only occur where there is a free face, such as the steep sided valleys, which are characteristic of the Southern Coalfield of NSW. In this coalfield, vertical cliff faces may be greater than 100 m high. This behaviour is confirmed by the strong influence on the magnitude and direction of horizontal movements of the surface topography detailed in the 2009 AusIMM subsidence paper. In the less severe topography above the project longwall mining areas, no significant far field effects are expected.

4.1.2 A and D Seam Surface Strain

Bending and horizontal movements in the strata cause surface strain. Measured strain is determined from monitored survey data by calculating the horizontal change in length of a section of a subsidence profile and dividing this by the initial horizontal length of that section.

The maximum predicted tensile strains after the extraction of both the A and D Seams range in magnitude up to 36 mm/m (**Figure 19**). In all cases, maximum tensile strains are expected to occur over the chain pillars. Maximum compressive strains range up to 31 mm/m.

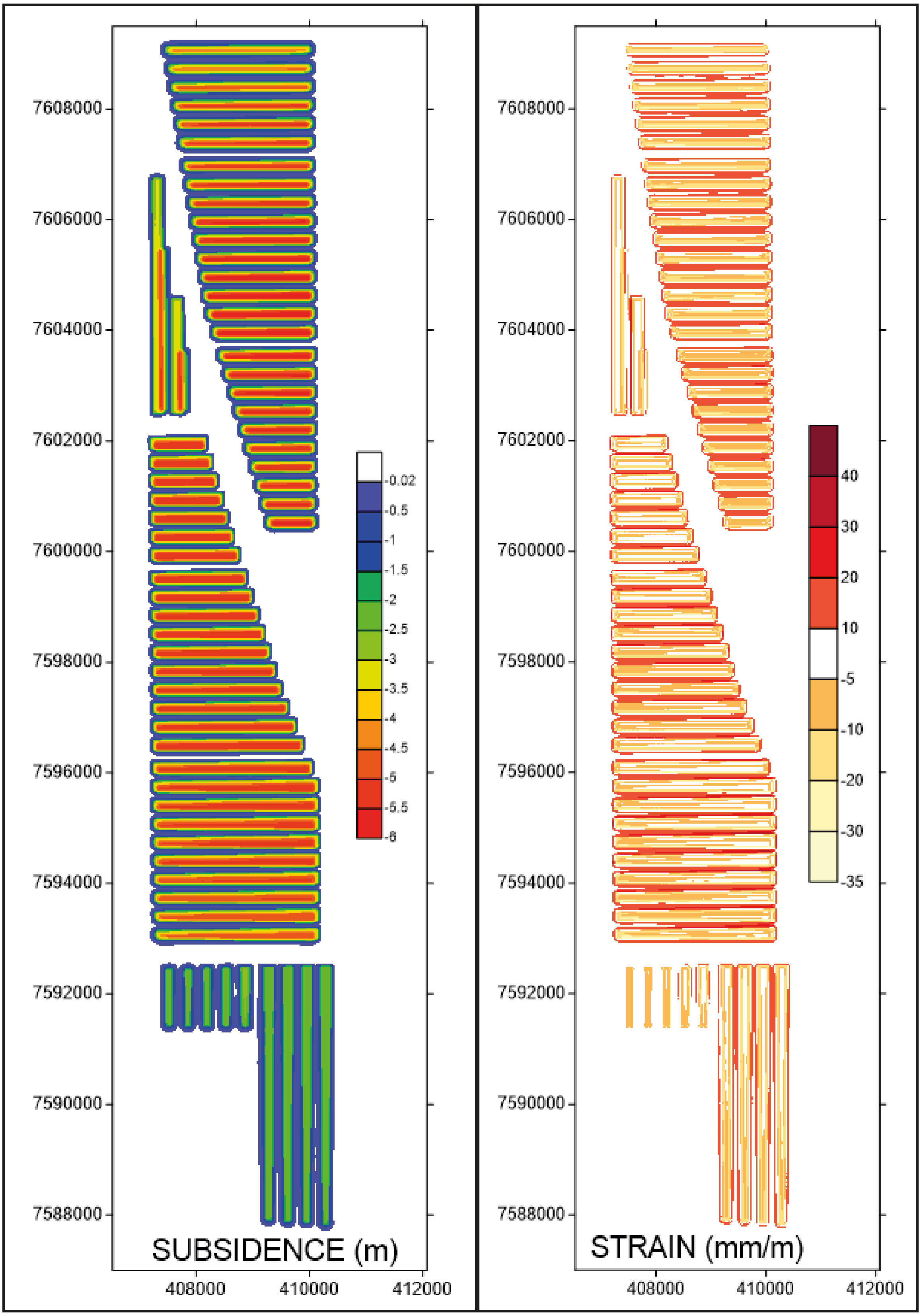

Figure 19. Subsidence and Strain due to A and D Seam Longwall Extraction.

4.1.3 A and D Seam Tilt

Tilt is the slope of subsided land over a given distance and is calculated by determining the change in subsidence between two points and dividing this by the distance between those points. The physical result is that the post mining surface slopes become steeper in localized areas along the edges of the subsidence troughs. Maximum tilts developed on the surface after the extraction of both the A and D Seam range up to 11% or 110 mm/m (**Figure 20**).

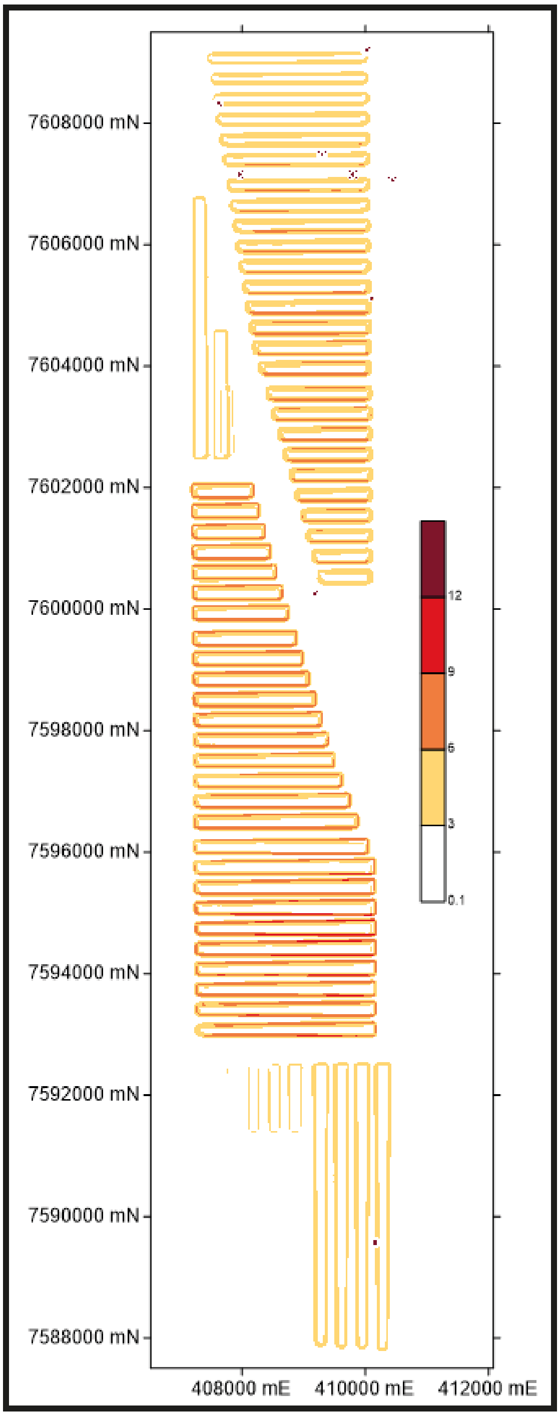

Figure 20. Tilt due to A and D Seam Longwall Extraction (%).

4.1.4 D Seam Subsidence, Strain and Tilt

The subsidence effects due to D Seam extraction only, are also presented in **Figure 21**. A maximum vertical subsidence of 2.6 m is predicted above Longwalls D902 and D903 (**Figure 21**). Maximum compressive and tensile strains are 11 mm/m above longwalls D901 to D903. Similarly, maximum tilts approach 3.9 % or 39 mm/m above the same longwalls.

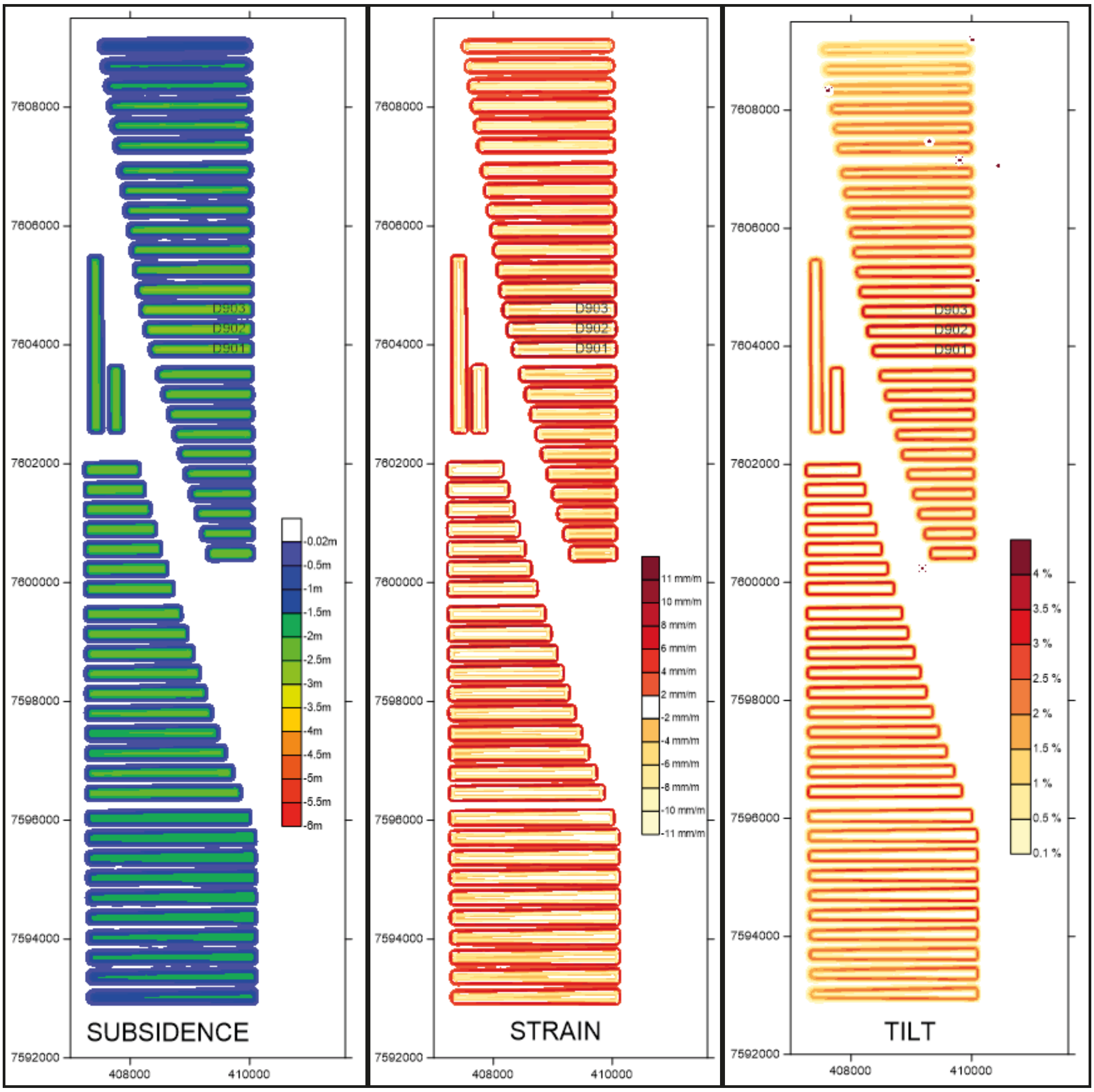

Figure 21. Subsidence, Strain and Tilt due to D Seam Longwall Extraction.

4.1.5 Cross Sections

Subsidence profiles can also be graphically represented on cross lines such as those shown in **Figure 22**, across the proposed longwall mining areas. It should be highlighted that these sections have a **very large vertical exaggeration** such that the tilts shown in the figures are very much larger than will be induced by the subsidence. The subsidence, strain and tilt profiles along cross line 1 in the Northern Underground area are shown on **Figure 23**.

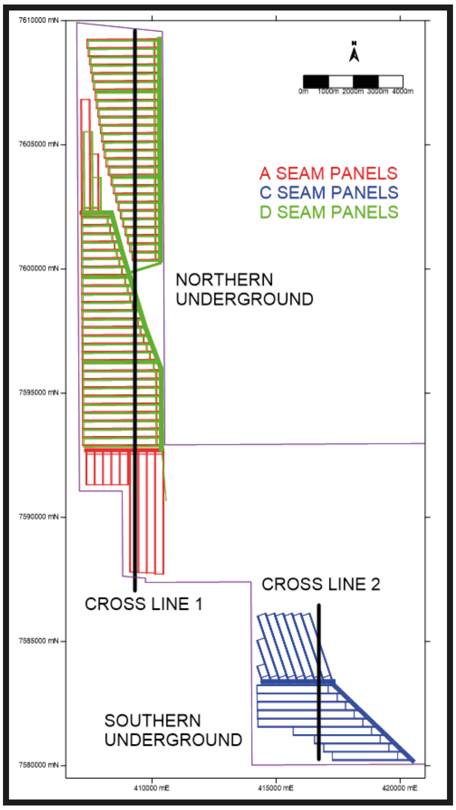

Figure 22. Location of Cross Lines.

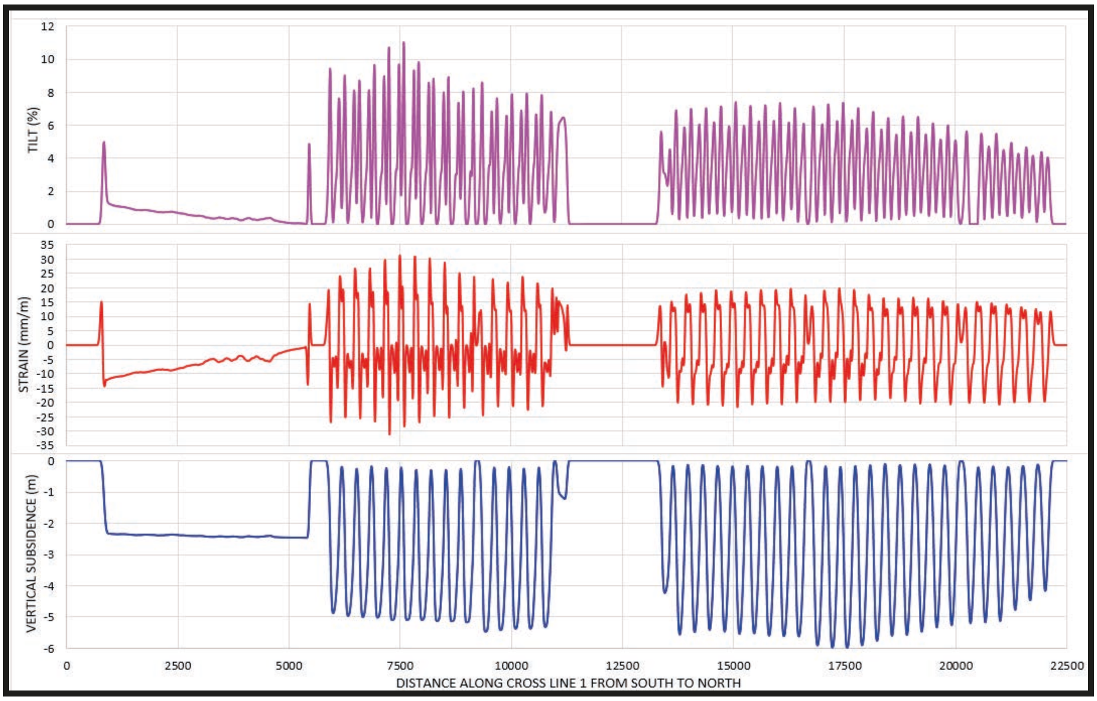

Figure 23. Subsidence, Strain and Tilt along Cross Line 1.

4.2 Southern Underground

4.2.1 C Seam Subsidence

Predicted subsidence from the C Seam longwall mine is shown in **Figure 24**. Vertical subsidence reaches a maximum of 2.7 m in the shallower mining areas. In the deepest part of the mining area maximum subsidence reduces to <2.2 m.

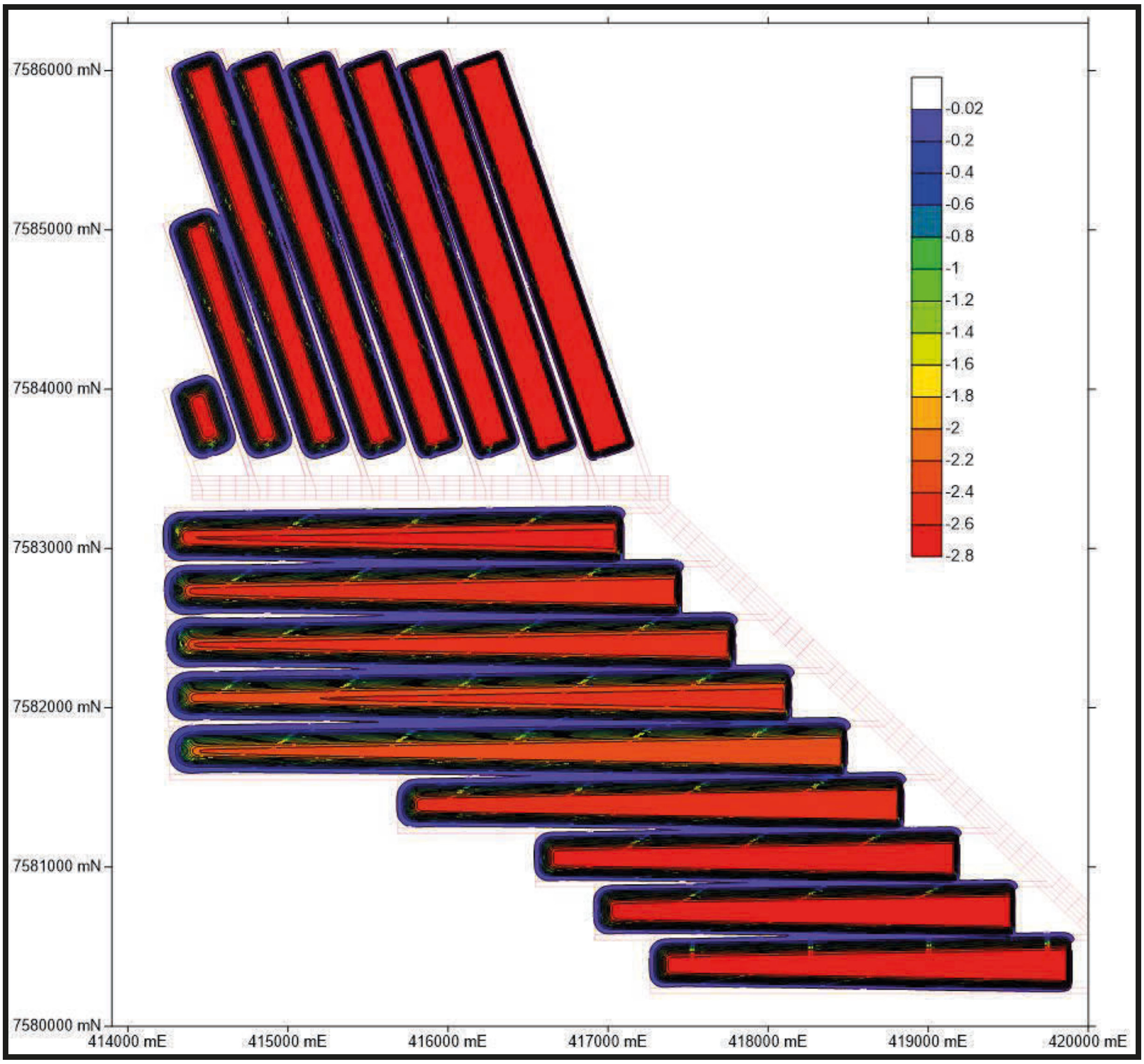

Figure 24. Subsidence due to C Seam Longwall Extraction (m).

4.2.2 C Seam Surface Strain

The maximum tensile strains caused by the C Seam longwall extraction range in magnitude up to 59 mm/m (**Figure 25**). Maximum compressive strains range up to 55 mm/m.

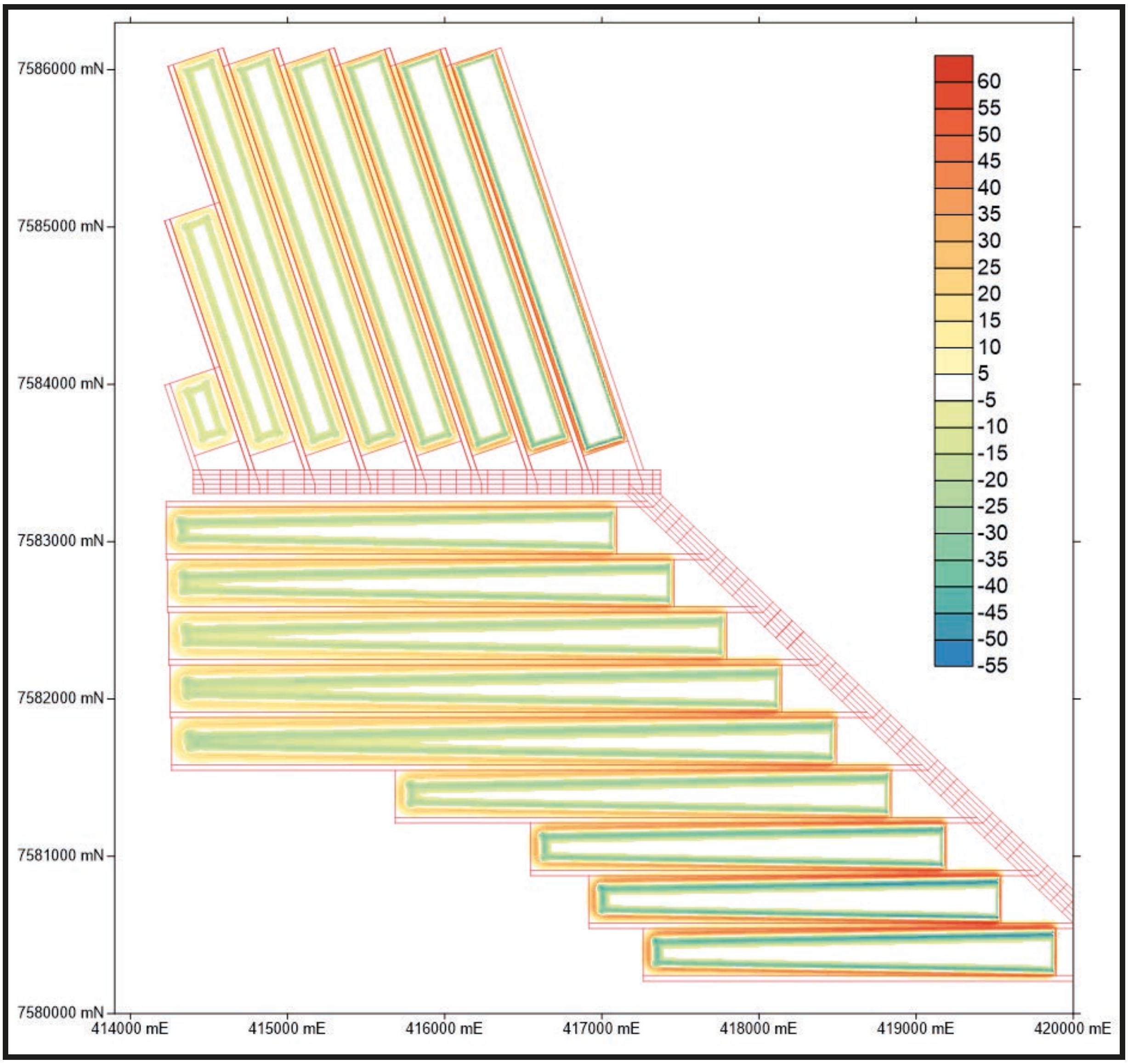

Figure 25. Strain due to C Seam Longwall Extraction (mm/m).

4.2.3 C Seam Tilt

The maximum tilts developed due to extraction of the C Seam longwalls are higher than in the shallowest part of the Northern Underground. They range up to 16.5% or 165 mm/m in the shallower, southeastern corner of the Southern Underground (**Figure 26**).

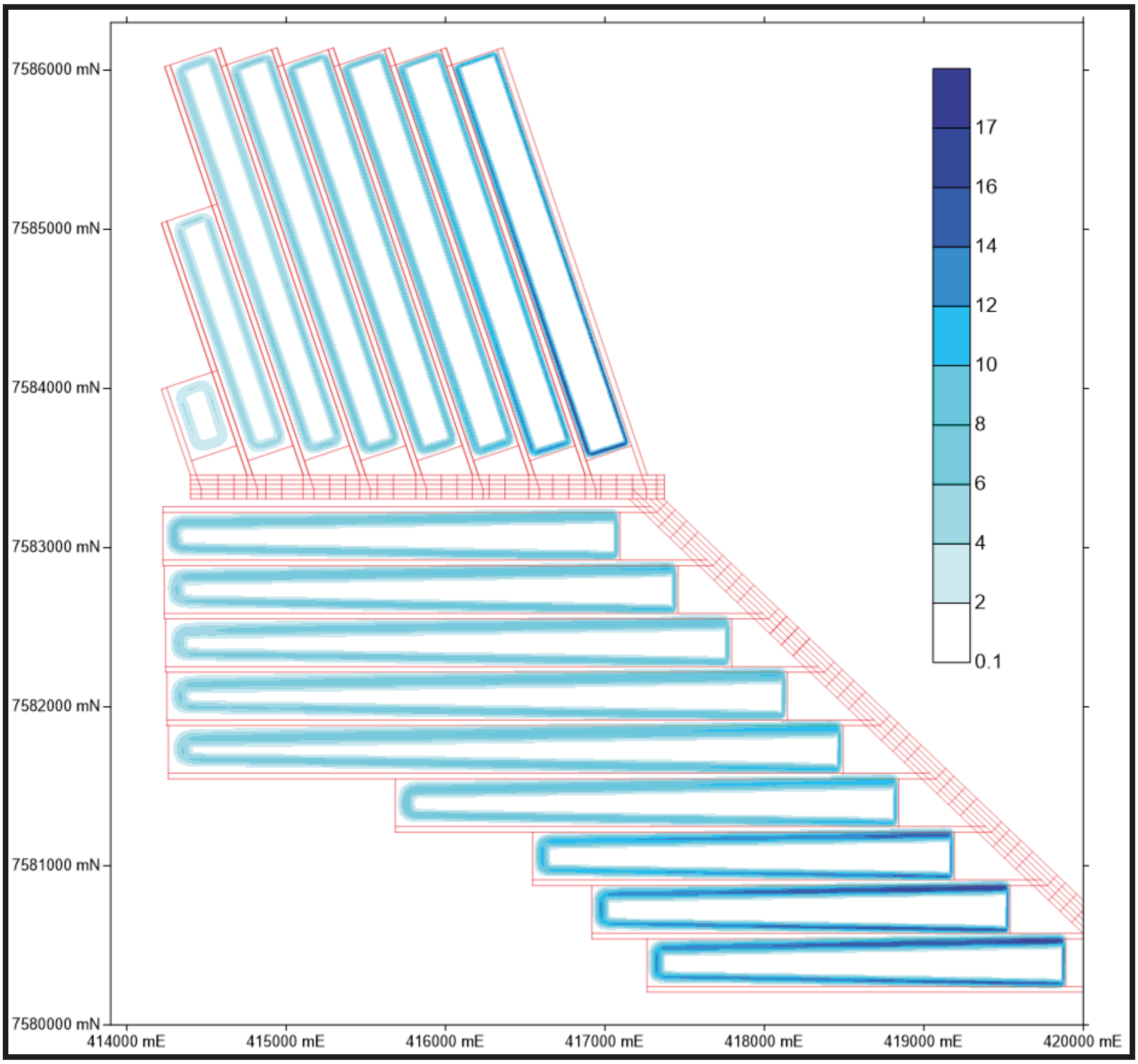

Figure 26. Tilt due to C Seam Longwall Extraction (%).

4.2.4 Cross Sections

The subsidence, strain and tilt profiles along cross line 2 in the Southern Underground area are shown on **Figure 27**.

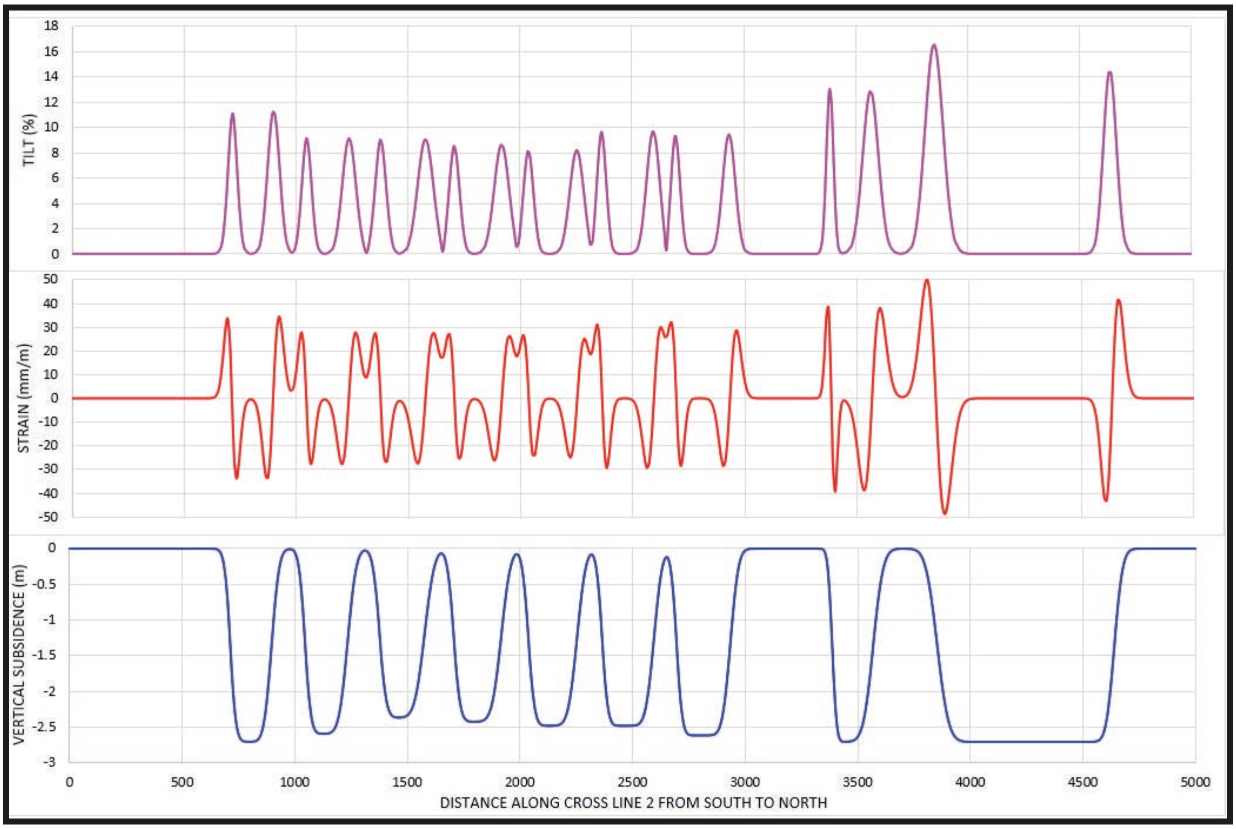

Figure 27. Subsidence, Strain and Tilt along Cross Line 2.

4.3 Limitations of the Subsidence Predictions

The subsidence predictions represent final subsidence values after longwall mining is completed. The nature of the longwall mining method means that subsidence does not increase further over time. Based on subsidence monitoring in the neighbouring Bowen Basin, greater than 97% of the maximum subsidence at a point on the surface typically occurs within 6 weeks after longwall mining has retreated past this point, assuming an industry average retreat rate of 100 m/week.

Based on the available data for the proposed longwall mining areas, there are no localised features or variations in the geology, geotechnical conditions or surface topography that are considered likely to result in any significant deviations from the subsidence predictions presented in this report.

As is good engineering practice, a review of the predictions should be conducted as any new geological/geotechnical data and subsidence monitoring becomes available. This is particularly relevant to the extraction of the A Seam above D Seam longwall panels, due to the limited availability of empirical data for dual seam extraction.

Overall, the subsidence predictions are based on well established methodologies that have been proven to provide reliable predictions at numerous similar mining operations. In any areas of uncertainty, conservative assumptions have been applied. The predictions are therefore considered suitable for assessing the potential significant impacts of subsidence on the environment.

5 SUBSIDENCE EFFECTS

The previous section has documented the predicted surface subsidence associated with the proposed longwall mining. This section provides an assessment of the effects that subsidence may have on both the overburden rock mass and the surface.

5.1 Surface Deformations

An indication of the range of predicted subsidence deformations associated with the proposed longwall mining is shown in the cumulative frequency curves in **Figure 28 and Figure 29**.

After the extraction of both the A and D Seams, 95% of the strains will be less than 20 mm/m. 80% of the tilts will be less than 50 mm/m, which is equivalent to a change in slope of 2.9 degrees.

For the C Seam extraction 70% of the tilts will be less than 50 mm/m (**Figure 29**). Most of the strains (90%) are less than 30 mm/m.

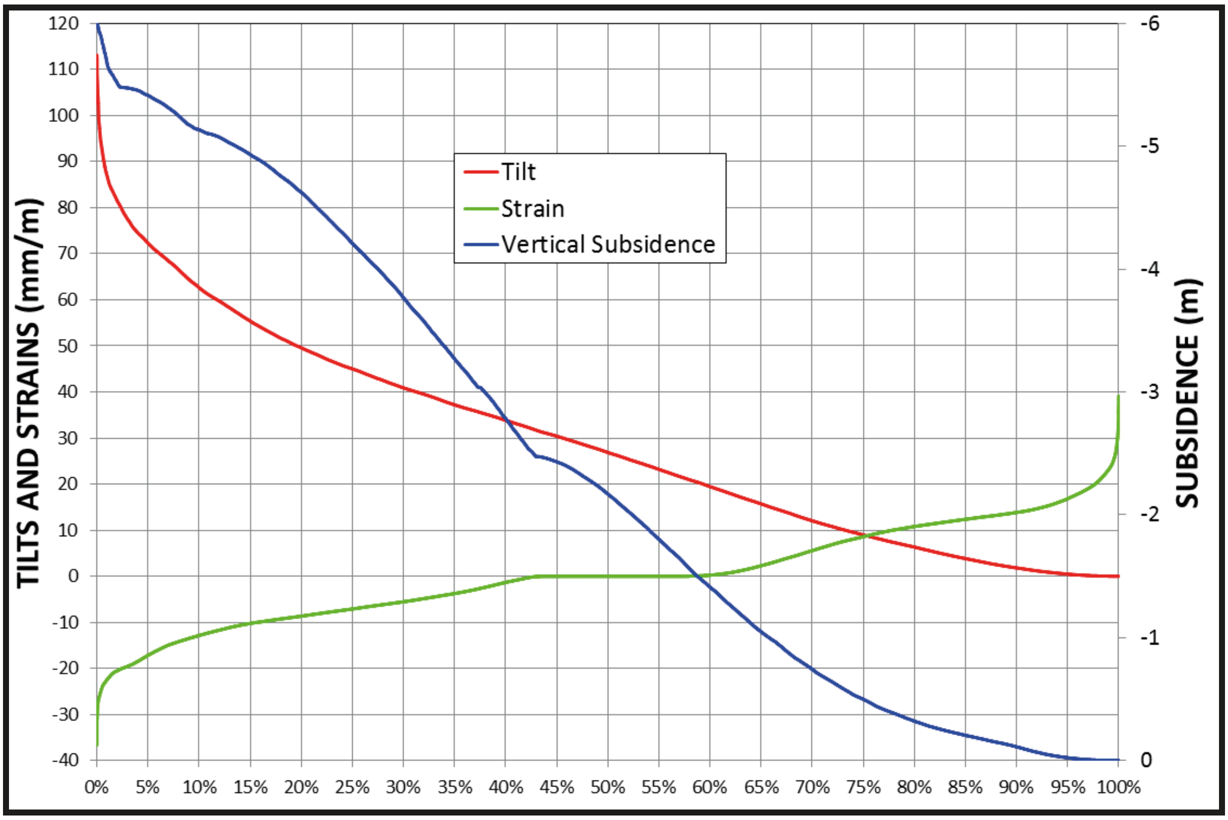

Figure 28. Cumulative Frequency Curves after Extraction of both the A and D Seams.

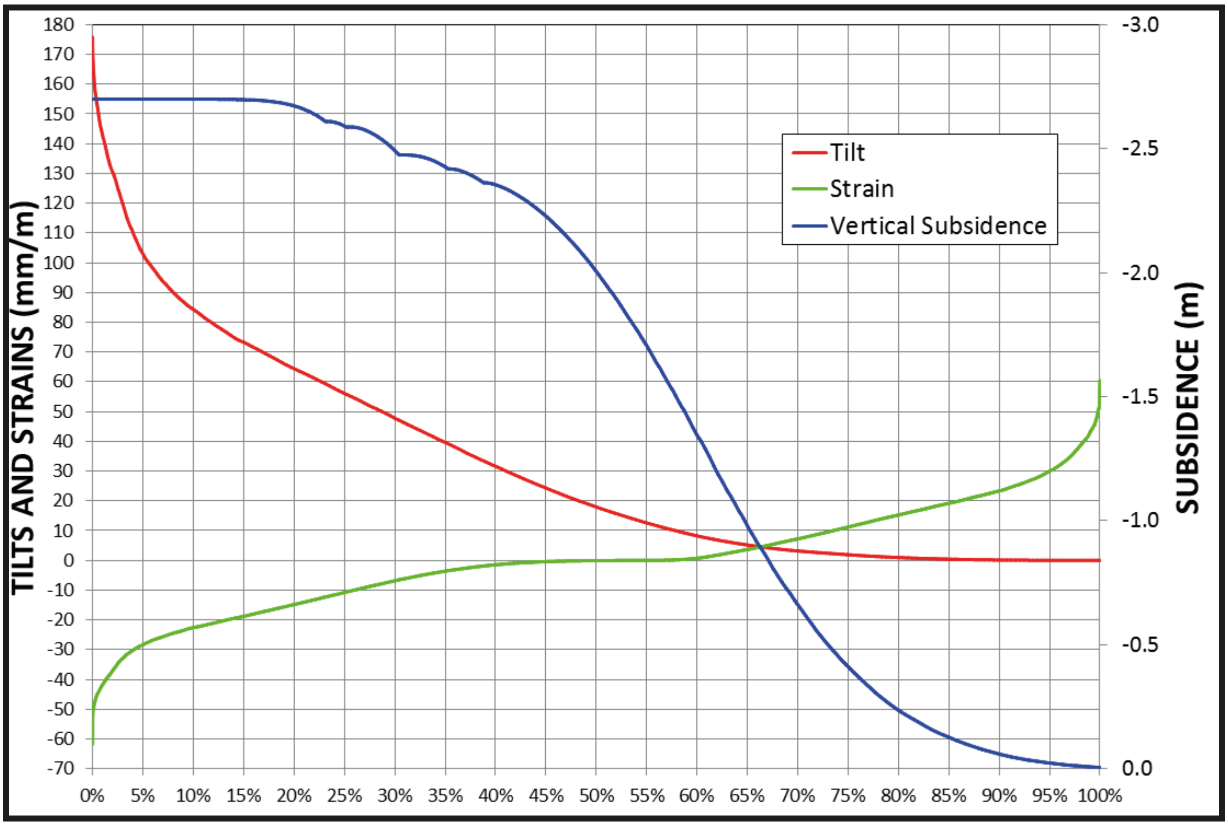

Figure 29. Cumulative Frequency Curves after Extraction of C Seam.

5.2 Subsurface Subsidence Cracking

5.2.1 Background to Subsurface Subsidence Cracking

Longwall mining methods can induce a range of subsurface subsidence effects. In the context of changes to the hydrogeological regime, the key issue associated with longwall subsidence is the creation of subsurface subsidence cracks in the rock mass. These cracks may provide new flow paths for groundwater and alter the permeability of the strata overlying longwall mining areas. The potential changes in the hydrogeological characteristics of the rock mass are dependent upon a number of variables that may affect the behaviour of subsurface subsidence cracking, such as:

- Mine geometry;
- Extracted seam thickness;
- Thickness and geomechanical properties of the overburden;
- Presence of tuffaceous horizons that may restrict the vertical flow of groundwater; and
- The bulking and compaction of the goaf material.

For operating longwall mines, it is possible to measure key subsurface subsidence cracking characteristics including the height of cracking above the extracted coal seam. This information can be correlated to measured changes in the water regime, for example decreases in groundwater levels in boreholes or inflows to underground mining areas. This provides accurate site-specific data on the known characteristics and impacts of subsurface subsidence cracking within the geological sequence.

A range of different methodologies are used to determine the heights of subsurface subsidence cracking associated with existing mining operations, such as:

- borehole extensometers;
- piezometer records;
- drilling records;
- comparison of permeability testing; and
- microseismic monitoring.

5.2.2 Prediction of Subsurface Subsidence Cracking Effects due to Single Seam Extraction

The prediction of subsurface subsidence cracking for single seam extraction has been extensively studied using both empirical and numerical modelling methods.

Models based upon empirical evidence such as observation and measurement are commonly used to predict the effects of subsidence. Empirical hydrogeological models for subsided strata are typically based on the interpretation of water inflow events.

The most commonly cited empirical model developed for predicting subsurface subsidence cracking effects on groundwater and surface water is the Bai and Kendorski (1995)[7] model (**Figure 30**). The key principle of this model is that subsurface subsidence cracking can be characterised by the following zones:

- Constrained zone – unaffected by subsurface subsidence cracking.
- Dilated (or discontinuous cracking) zone – no changes in vertical permeability, possible changes in horizontal permeability and storativity.
- Fractured (or continuous cracking) zone – changes in vertical and horizontal permeability are possible.

In this model, cracking within the dilated (or discontinuous cracking) zone is dominantly horizontal, with negligible vertical cracks. In this zone, there may be an increase in horizontal permeability but this is not likely to result in significant inflows to the underground mine workings. The fractured zone nomenclature is related to the zone of vertical hydraulic connectivity (or unrestricted inflow) and does not imply the limit of all cracking.

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[7] Bai, M, and Kendorski F.S. (1995). Chinese and North American high extraction underground coal mining strata behaviour and water protection experience and guidelines. 14th Conference on Ground Control in Mining. 209-217.

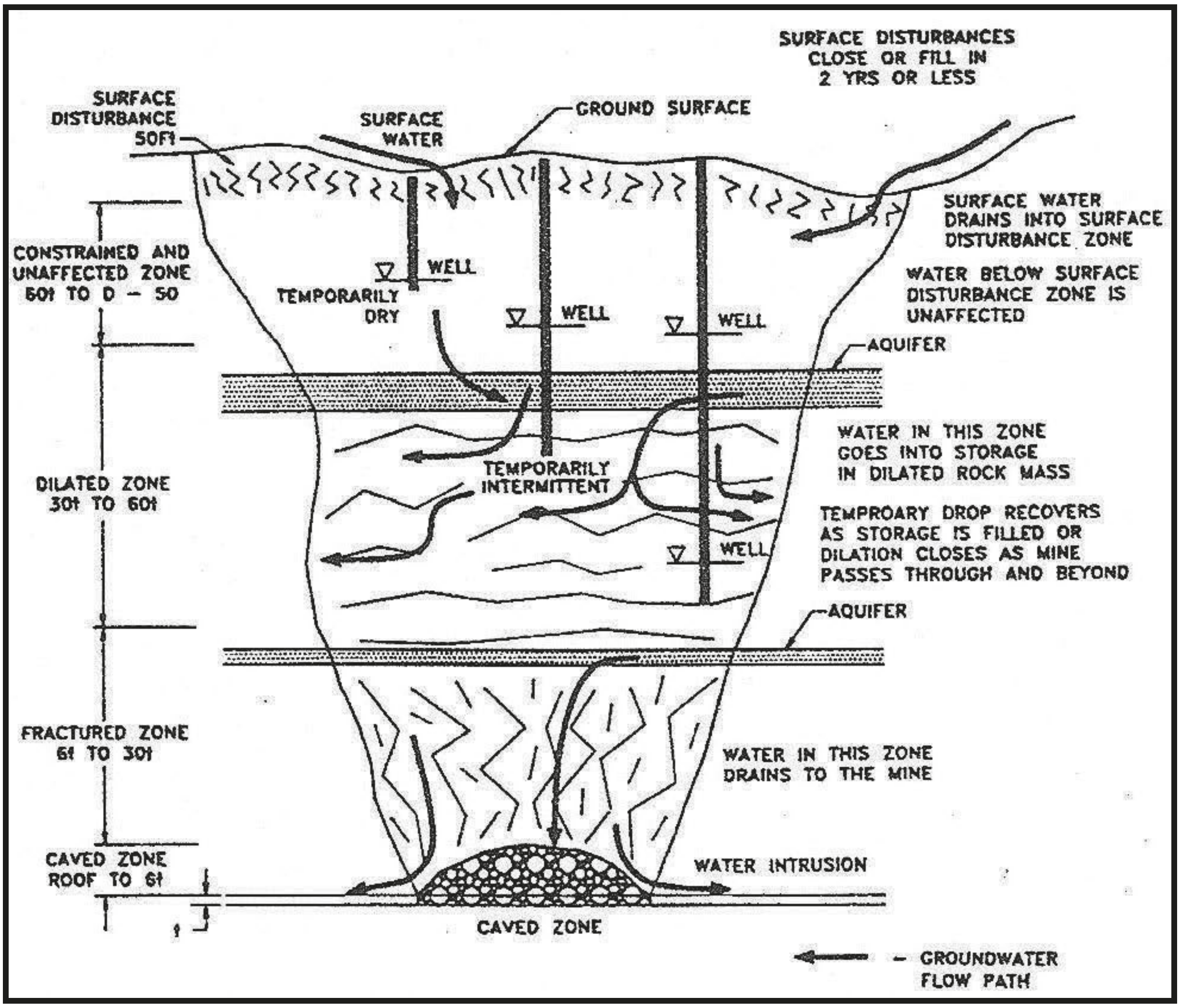

Figure 30. Hydrogeological Model for Cracking above Longwalls (Bai & Kendorski, 1995).

This model concludes that water will enter an underground mine or be lost from an aquifer or surface water body if:

- the zone of continuous subsurface cracking intersects the water body, or
- there is a connection between the continuous subsurface cracking zone and any surface subsidence cracking.

The heights of subsurface subsidence cracking in models such as that of Bai and Kendorski are related to extracted coal thickness. In **Figure 30**, the fractured zone is shown to range from 6 to 30 times the extracted seam thickness.

Alternative models are available which relate the height of continuous cracking to the mining induced tensile strains and depths of cover. However, the overall concept of dividing the rock mass into different cracking zones is common to all methods and is a well-established and valid approach to explain the measured differences in field observations arising from subsurface subsidence cracking.

Measured data taken from comparable mining operations in equivalent geology can also be used to assist with the prediction of the likely extent of each subsurface cracking zone and, in particular, the boundary between discontinuous and continuous zones of subsurface subsidence cracking.

The behaviour of the subsided rock mass can also be assessed using numerical modelling methods. Commercially available modelling software includes the Fast Lagrangian Analysis of Continua (FLAC) model.

Numerical modelling of subsurface cracking requires robust calibration, verification and validation to minimise the potential for erroneous results and requires reference to measured data. For a greenfield project with no site specific monitoring data available, a numerical model would need to be calibrated against measured data from other similar mine sites. Consequently, numerical modelling would not provide a higher level of accuracy than empirical methods in the prediction of subsurface cracking for a greenfield project, as the basis of the predictions would be essentially the same.

5.2.3 Prediction of Subsurface Subsidence Cracking Effects due to Dual Seam Extraction

GGPL is not aware of empirical studies examining the height of subsurface cracking above dual seam longwalls; however, some recent physical modelling work by Ghabraie and Ren (2014)[8] is detailed below to provide an understanding of the subsurface strata movement in a dual seam longwall mine.

Ghabraie and Ren (2014) built a physical model to investigate the mechanism of surface and subsurface movements of the strata in a dual seam longwall environment (**Figure 31**). The upper seam, located 24 m above the lower seam, was extracted first. The panel width in both seams was 120 m and the extraction height was 4.5 m. The depth of cover above the upper seam was 80 m, indicating supercritical subsidence behaviour (panel width to depth of cover ratio of 1.5).

As shown in **Figure 31**, some reworking of the upper seam goaf occurs when the lower seam is extracted. The model indicates that the height of cracking above the upper seam is increased once both seams are extracted. It is noted that additional cracking was not observed outside the previously caved zone. A conceptual model for this reworking of the upper seam goaf is shown in **Figure 32**.

In the Northern Underground the extraction sequence is reversed, with the lower D Seam extracted before the upper A Seam. The interburden between the seams is 50-70 m, which is also greater than modelled by Ghabraie and Ren (2014). The implication of this geometry is that the amount of strata in the fractured zone above the A Seam would be expected to be less than that shown in the physical model in **Figure 31**. In summary, whilst the physical model has some differences to the

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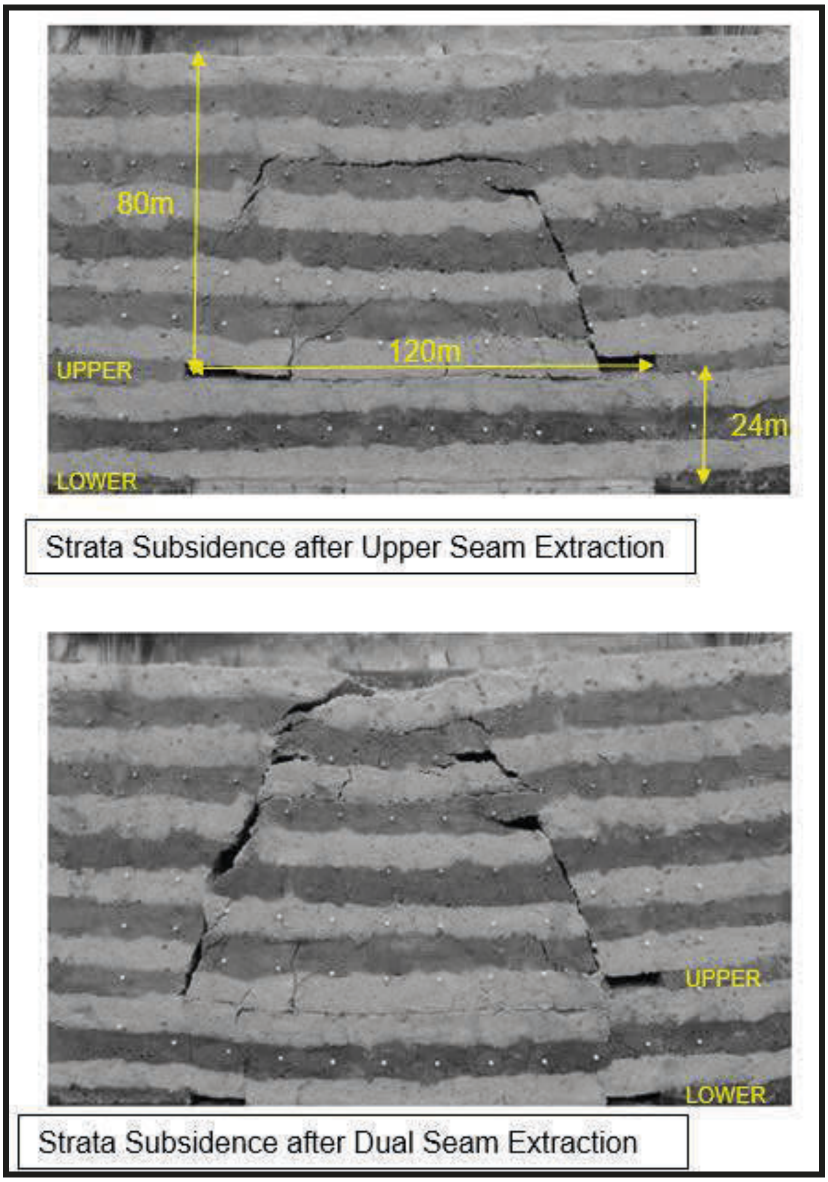
[8] Ghabraie, B and Ren, G. (2014). Investigating characteristics of strata movement due to multiple seam mining using a sand-plater physical model. Proceedings of the 9th Triennial Conference on Mine Subsidence.

proposed dual seam mining in the Northern Underground, it provides useful insight to the potential subsurface cracking mechanisms for dual seam mining.



Strata Subsidence after Upper Seam Extraction

Strata Subsidence after Dual Seam Extraction

Figure 31. Results of Physical Modelling of Dual Seam Subsidence (Ghabraie and Ren, 2014).

Ghabraie and Ren (2014) found that the initial cracks formed by the extraction of the first seam could change the crack propagation above the second seam extracted. Subsidence from the extraction of the second seam opens up existing cracks and induces greater bedding separation. This is highlighted by the different displacement profiles for the two mining scenarios (**Figure 32**). The subsurface strata cracking profile after extraction of the first seam shows a balanced movement between horizontal and vertical components (**Figure 32**). In comparison, after the second seam is extracted the vertical movement is mainly restricted to a wedge shaped area, shown by dotted red line in **Figure 32**. Outside this wedge area, the horizontal displacement is the predominant displacement component.

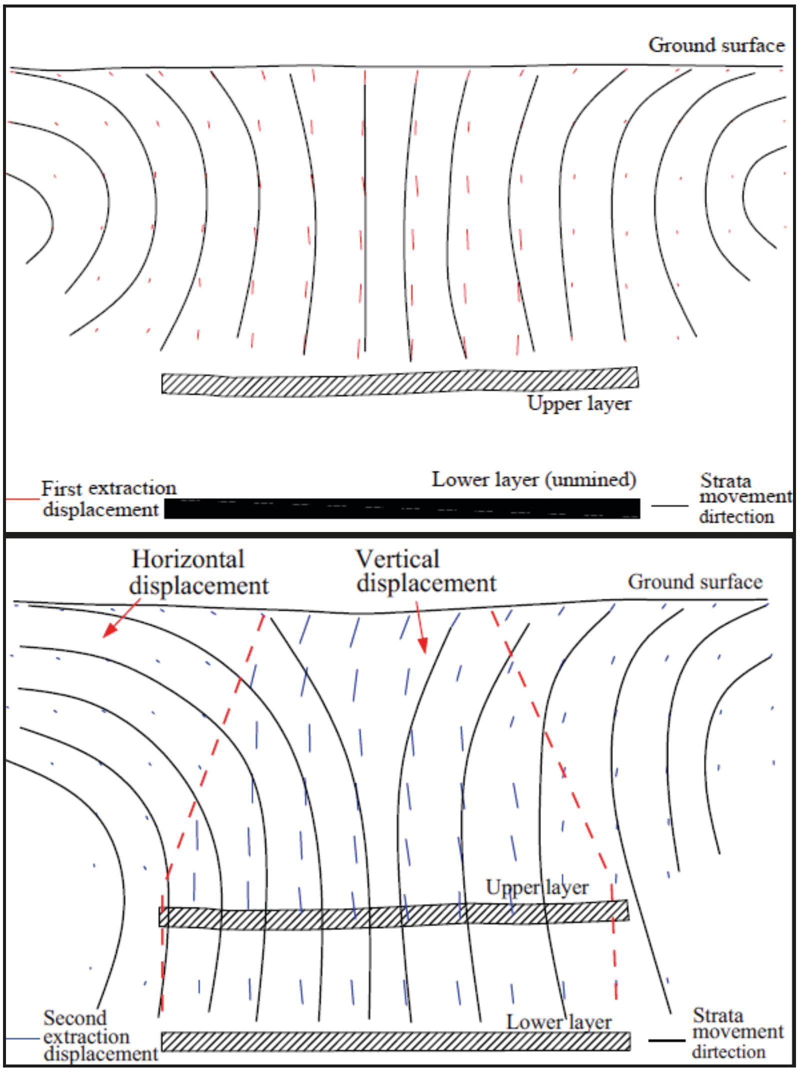


Figure 32. Displacement Profiles of Upper and Lower Seam Extraction (Ghabraie and Ren, 2014).

5.2.4 Comparative Assessment of Subsurface Subsidence Cracking Predictions for Single Seam Extraction

5.2.4.1 Water Inflow Events in the Bowen Basin

Seedsman and Dawkins (2006)[9] provide a comprehensive summary of subsurface subsidence cracking and water inflow events in the Bowen Basin.
Seedsman and Dawkins report that:

- no major surface water inflows to longwall mining areas have occurred in the Bowen Basin where the depth of cover has exceeded 120 m; and
- no major groundwater inflows to longwall mining areas have occurred in the Bowen Basin where the distance from the seam to the aquifers is more than approximately 90 m.

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[9] Seedsman, R.W. and Dawkins, A. (2006). Techniques to predict and measure subsidence and its impacts on the ground water regime above shallow longwalls. ACARP Project C13009.

Klenowski (2000)[10] reports on the inflow of water at the Oaky Creek Mine and the German Creek Mining Complex in the central part of the Bowen Basin. These mines target the German Creek Coal Measures, which comprise a sequence of sandstones, siltstones, mudstones and coal seams similar to the project site.

Klenowski concluded that unrestricted inflow (i.e. from the zone of continuous cracking) generally occurs to a height of about 120 m above the active mine area. The inflow rates for different heights of cracking in the German Creek mining complex, as well as other comparable mining operations, extracting single seam longwalls, throughout the Bowen Basin, Australia and overseas, are plotted in **Figure 33**. These conclusions are consistent with the mining conditions at the Aquila mine at German Creek, where no significant cracking or slabbing of the strata was encountered in workings developed 110 m above extracted goaf.

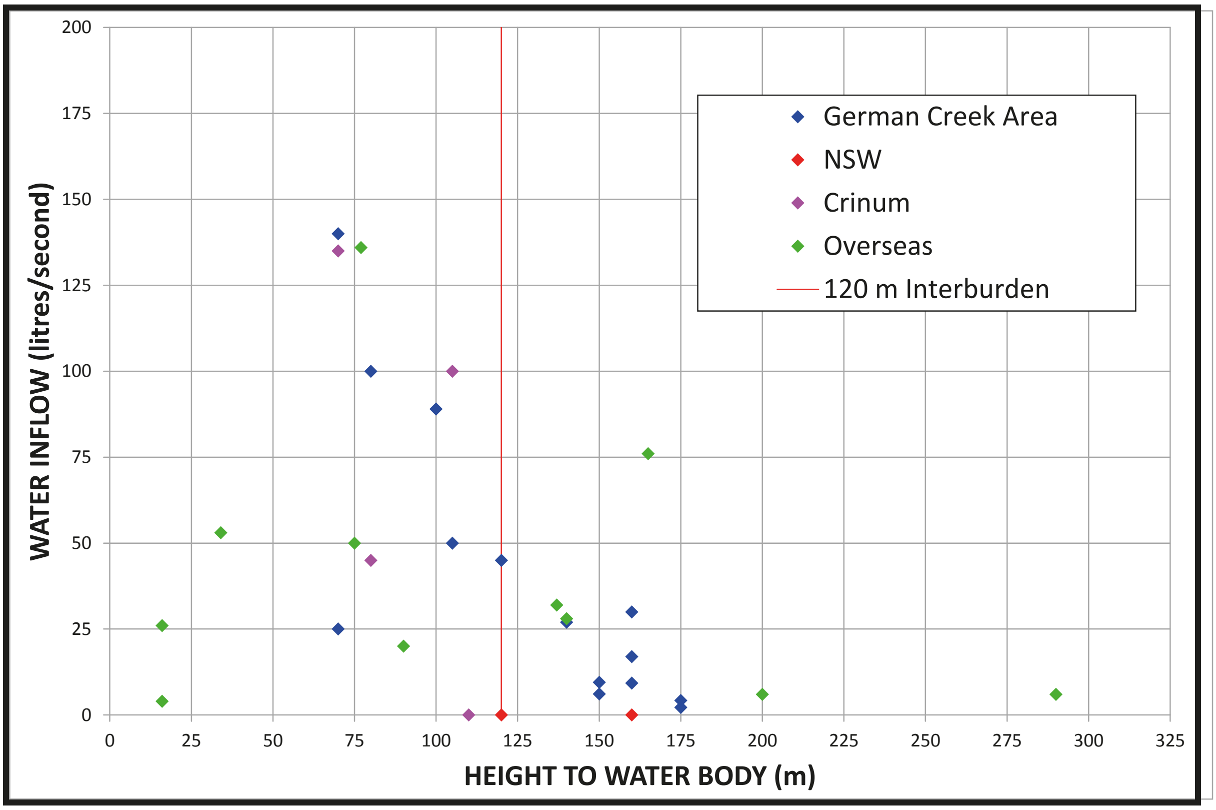

Figure 33. Summary of Water Inflow Events.

Evidence from Crinum Mine and Kestrel Mine, suggests that the presence of Tertiary clay materials in the overburden within the cracking zone may have retarded water inflow rates to underground workings (Seedsman & Dawkins (2006), Gale (2008)).

5.2.4.2 Microseismic Monitoring Data

Microseismic monitoring involves the use of geophones installed in boreholes to record the development of fractures by measuring microseismic events.

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[10] Klenowski, G. (2000). The influence of cracking on longwall extraction. ACARP Project C5016.

Microseismic monitoring is one of the most reliable tools for determining the interface between continuous and discontinuous subsurface subsidence cracking. Published monitoring data is available from two Bowen Basin longwall mines.

At North Goonyella Mine, microseismic monitoring of a 250 m wide longwall panel, at approximately 150 m depth of cover was carried out. The extraction height was up to 4 m high. As shown in **Figure 34**, the majority of microseismic events occur within 120 m of the extracted seam. These results indicate the monitored limit of continuous cracking is 120 m.

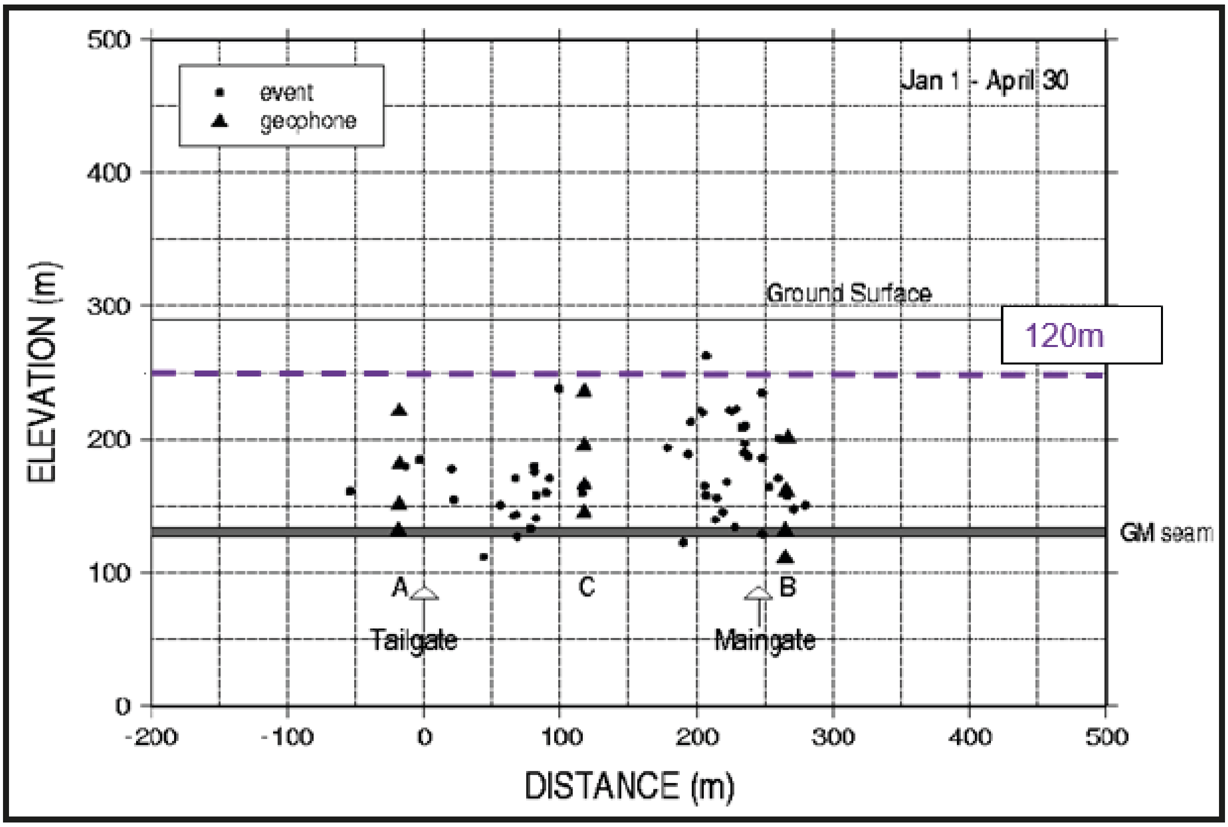

Figure 34. Location of Microseismic Events above LW3 at the North Goonyella Mine (Kelly and Gale, 1999).

Microseismic monitoring above the 200 m wide, Longwall 101 panel at Kestrel Mine indicates a marked reduction in events (i.e. cracking) at 90 m above the seam (**Figure 35**). This was taken to be the limit of monitored continuous cracking. No microseismic events were recorded higher than 115 m above the extracted seam (**Figure 35**). The depth of cover and extraction height in this area of the mine was 220 m and 3 m, respectively.

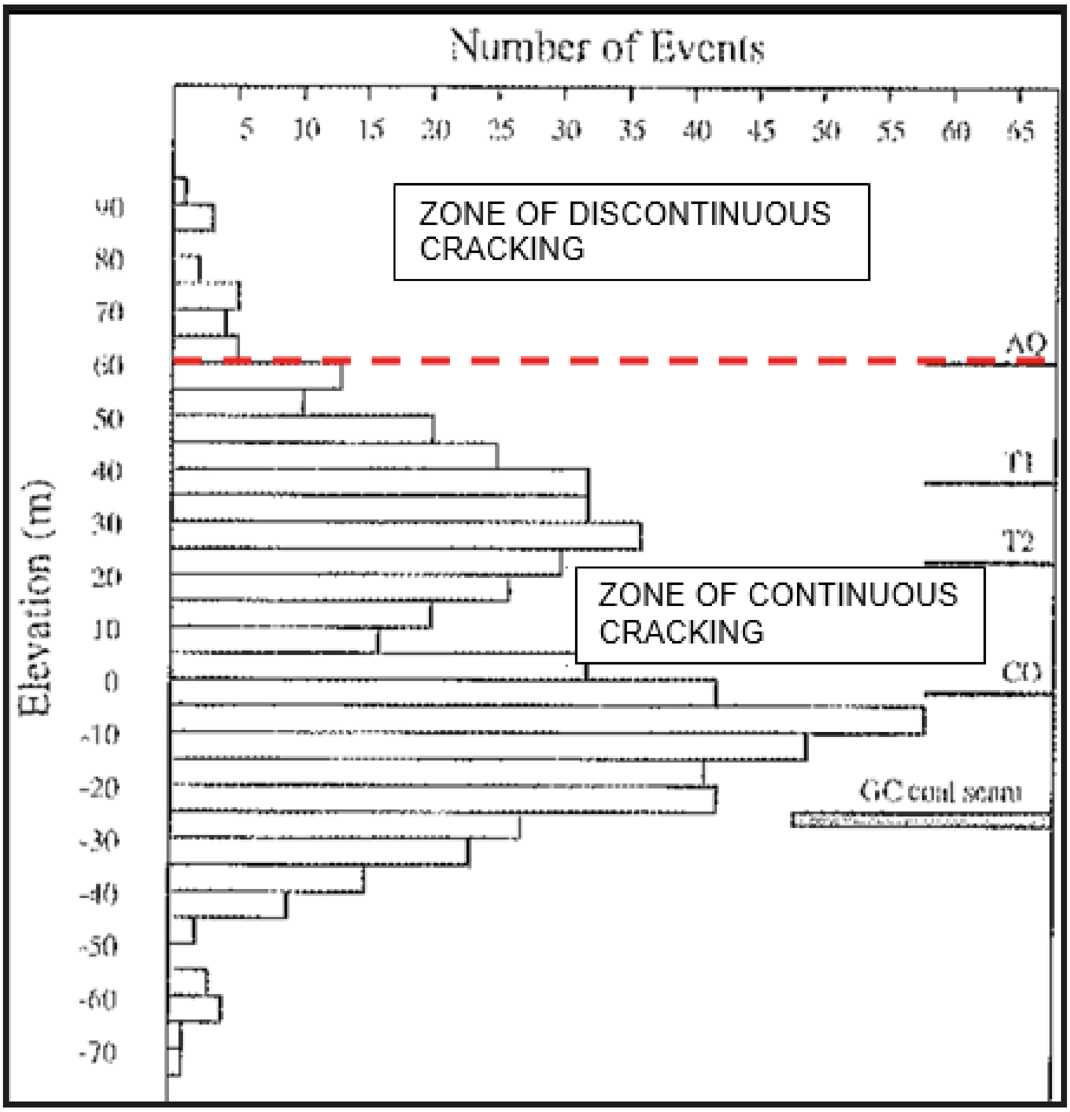

Figure 35. Location of Microseismic Events around LW101 at Kestrel Mine (Kelly and Gale, 1999[11]).

5.2.4.3 Numerical Modelling

Published numerical modelling studies by Gale (2008) in the Oaky Creek area showed a distinct decrease in the vertical conductivity to around 10^{-6} m/s, at beyond 90 to 100 m above the coal seam (**Figure 36**). This is also consistent with the field observations described above. The progressive reduction in vertical conductivity from 1 m/s close to the extracted seam, decreasing to 10^{-4} m/s at the top of continuous cracking zone is also clearly evident in **Figure 36**.

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[11] Kelly, M. and Gale, W. 1999. Ground behaviour about longwall faces and its effect on mining. ACARP Project C5017.

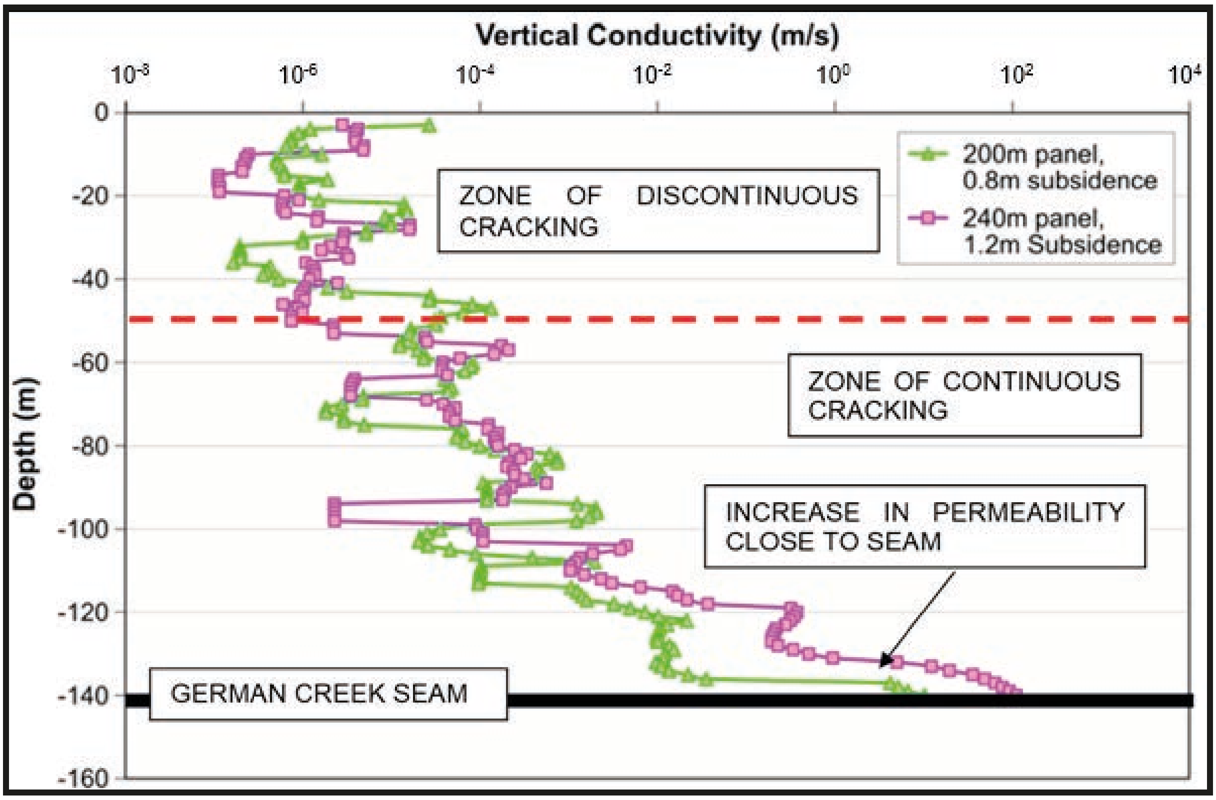

Figure 36. Vertical Conductivity through a Numerical Model in the Oaky Creek Mining Area (Gale, 2008[12]).

5.2.4.4 Summary of Data

Field observations of heights of subsurface subsidence cracking from mines in QLD, NSW and overseas are summarised in **Table 2**.

Gale (2008) also reports that 105 m of rock head is used as a standard buffer distance to minimise the risk of inflow events in the UK.

These thicknesses are consistent with monitoring conducted in NSW mines, where the potential for surface water to flow into underground longwall workings is recognised if the longwall panel is less than 100 m to 150 m below the surface.

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[12] Gale, W. (2008). Aquifer inflow prediction above longwall panels. ACARP Project C13013.

Mining Area	Height of Cracking	Discussion/Evidence
Crinum, QLD	90-100 m	Height to overlying basalt/sand aquifers in the Tertiary (Seedsman and Dawkins, 2006).
NSW	100-150 m	The potential for surface water to flow into underground longwall workings is recognised if the longwall panel is less than 100 m to 150 m below the surface (Seedsman and Dawkins, 2006).
Oaky Creek and German Creek, QLD	<160 m	For ponded water at cover depths greater than 160 m, remedial works are generally not required and standard underground pumping systems are capable of handling minor increases in flow (Klenowski, 2000). Unrestricted inflow generally occurs to a height of about 120 m above the active mine area, with inflow rates progressively reducing as the depth of cover increases above 120 m (Klenowski, 2000).
Kestrel, QLD	<115 m	Microseismic monitoring of Longwall 101. (Kelly and Gale, 1999).
North Goonyella	<120 m	Microseismic monitoring of Longwall 3. (Kelly and Gale, 1999).
Wyee, NSW	40-63 m	Wide panels and strong, massive roof strata (Forster and Enever, 1992)[13].
Cooranbong, NSW	58 m	Wide panels and strong, massive roof strata (Forster and Enever, 1992).
Wistow Mine, UK	77 m	Limestone aquifer (Whittaker and Reddish, 1989)[14].
UK	<105 m of rock head	Guideline to minimise the risk of inflow (Gale, 2008).
Northern Bowen Basin	<170-250 m	Longwalls (314 m wide and 4.5 m high) successfully extracted beneath the Isaac River.

Table 2. Field Observations and Guidelines for the Height of Cracking.

5.2.5 Conclusions

The estimation of the height and behaviour of subsurface subsidence cracking is a complex issue. Specifically relating to water impacts, there is no simple calculation to estimate the height of the continuous and discontinuous zones. The estimate is further complicated by the lack of monitoring data available for dual seam longwall extraction.

Reference to measured data and site-specific experience is a means of addressing this issue for single seam extraction. For dual seam extraction the physical model studies detailed earlier have been referred to for the project site.

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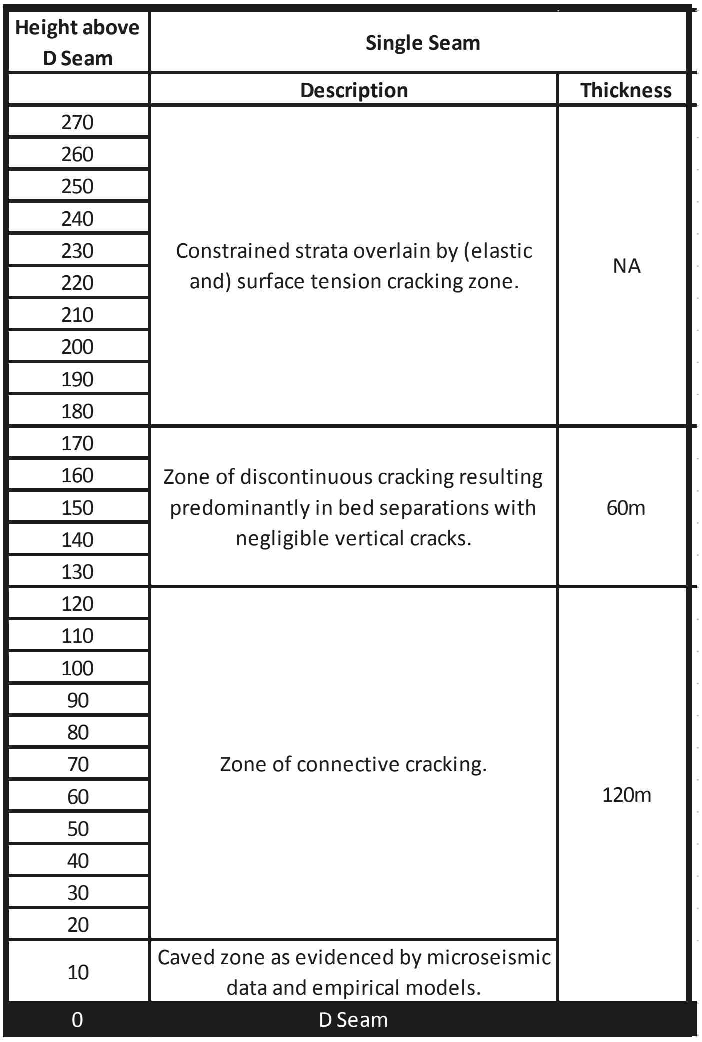
[13] Forster, I. and Enever, J. (1992). Hydrogeological response of overburden strata to underground mining, Central Coast, NSW. Office of Energy Sydney.

[14] Whittaker, B.N. and Reddish, D.J. (1989). Subsidence – Occurrence, Prediction and Control. Elsevier.

This approach is considered to provide a suitable basis for the assessment of the likely behaviour of subsurface subsidence for the project. With the available data, conceptual models for the subsurface subsidence effects in the project longwall areas of both single seam and dual seam extraction are discussed in the following sections.

5.2.5.1 Prediction for Single Seam Extraction

Based on the site-specific data from the Bowen Basin, including microseismic monitoring and documented unrestricted inflow events (section 5.2.4), an upper bound height of continuous cracking for single seam extraction is proposed at 120 m, as detailed in the conceptual model in **Table 3**. This is consistent with the available data from NSW and international longwall mining operations and hence provides a robust basis for the assessment of potential groundwater impacts associated with continuous cracking in single seam longwall mining areas. The empirical model of Bai and Kendorski indicates the height of cracking may be less than 120 m in areas where the D Seam extraction height is lower than 4 m (**Figure 30**).



Height above D Seam	Single Seam	
	Description	Thickness
270	Constrained strata overlain by (elastic and) surface tension cracking zone.	NA
260		
250		
240		
230		
220		
210		
200		
190		
180		
170	Zone of discontinuous cracking resulting predominantly in bed separations with negligible vertical cracks.	60m
160		
150		
140		
130		
120	Zone of connective cracking.	120m
110		
100		
90		
80		
70		
60		
50		
40		
30		
20		
10	Caved zone as evidenced by microseismic data and empirical models.	
0	D Seam	

Table 3. Conceptual Model of the Subsurface Subsidence Effects at Project China Stone for Single Seam Extraction.

5.2.5.2 Prediction for Dual Seam Extraction

The conceptual model proposed for dual seam extraction is shown in **Table 4** below. This model has referenced the physical modelling studies of Ghabraie and Ren (2014) to provide a better understanding of the failure mechanisms in the overburden. Due to potential weakening of the overburden strata in the discontinuous cracking zone above the A Seam, by the extraction of the D Seam, the zone of continuous cracking is conservatively inferred to extend to 180 m above the A Seam extraction (**Table 4**).

Height above A Seam	Height above D Seam	Dual Seam	
		Thickness	Description
220	280	NA	Constrained strata overlain by (elastic and) surface tension cracking zone.
210	270		
200	260		
190	250		
180	240		
170	230	60m	Zone of discontinuous cracking due to A Seam extraction resulting predominantly in bed separations with negligible vertical cracks.
160	220		This zone may have been weakened by extraction of the D Seam and there is the possibility of some connective cracking to account for uncertainties in the failure mechanism due to dual seam extraction.
150	210		
140	200		
130	190		
120	180		
110	170	60m	Previously discontinuously cracked zone experiences reworking of existing cracks and bedding. This increases the void and eventually causes failures, resulting in failure of the upper layers (ref Section 3, Ghabraie and Ren, 2014).
100	160		
90	150		This subsidence regime mainly involves opening existing cracks with minimal generation of new cracks. This results in a similar crack propagation profile to single seam extraction. Vertical displacement due to second extraction mainly restricted to the previously disturbed zone (ref Section 4, Ghabraie and Ren, 2014).
80	140		
70	130		
60	120		
50	110	60m	Zone where existing cracks and bedding are reworked (ref Section 3, Ghabraie and Ren, 2014). Vertical displacement due to second extraction mainly restricted to the previously disturbed zone (ref Section 4, Ghabraie and Ren, 2014). Subsidence regime mainly opening existing cracks with minimal generation of new cracks.
40	100		
30	90		
20	80		
10	70		
0	60		A Seam
	50	60m	Zone of connective cracking.
	40		
	30		
	20		
	10		Caved zone as evidenced by microseismic data and empirical models.
	0		D Seam

Table 4. Conceptual Model of the Subsurface Subsidence Effects at Project China Stone for Dual Seam Extraction.

This 50% increase from the predicted continuous cracking height for single seam extraction should more than adequately account for the uncertainty associated with dual seam extraction and therefore provide a conservative basis for the purposes of assessing potential worst case groundwater impacts.

5.2.5.3 Connective Cracking to the Surface

In any areas where the depth of cover to the extracted coal seams is less than the combined height of connective cracking and surface crack depth, connective cracking to the surface could potentially occur. There are three areas above the Northern Underground and an area above the southern end of the Southern Underground where the depth of cover is less than the predicted combined maximum connective cracking heights. These areas are shown in **Figure 37**. There are no significant surface drainage lines in these areas. These areas are also close to the top of the catchment where any surface runoff is highly ephemeral. Any surface cracks that develop in these areas would be sealed during crack rehabilitation.

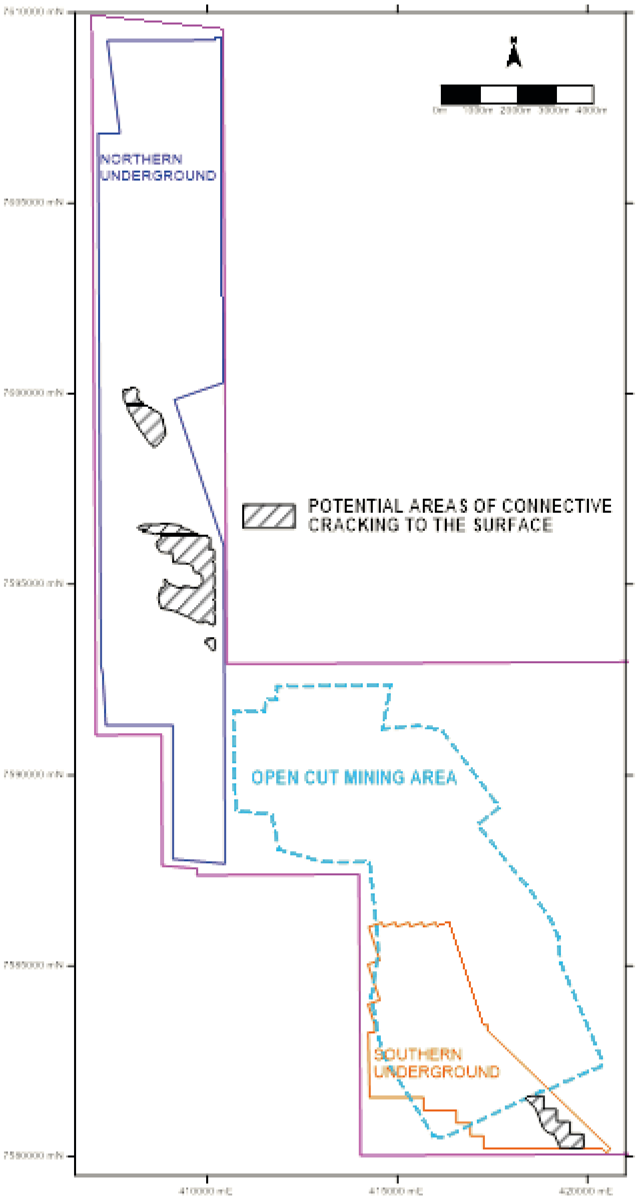


Figure 37. Areas of Potential Connective Cracking to the Surface.

5.3 Surface Cracking

5.3.1 Tension Cracks

Subsidence related cracking of the surface will develop in the proposed longwall mining areas. Whether it is discernible from the natural cracking that characterises some of the soils of the longwall mining areas will depend on the interaction between the cracks, the soil, and water. The areas with the highest potential for cracking are those located at the panel edges where the maximum tensile strain occurs.

It is noted that based on the principles of fracture mechanics, there is likely to be a direct relationship between crack width and crack depth i.e. narrow surface cracks will be shallower than wide cracks. Deeper and wider cracking could be associated with areas of high tensile strains. The widest of these cracks are predicted to extend to no more than 10-15 m below ground level based on the model of Bai and Kendorski (**Figure 30**).

5.3.1.1 Single Seam

MSEC (2007) also proposed a relationship between crack width and depth of cover with the severity and frequency of surface cracking reducing as the depth of cover increases (**Figure 38**).

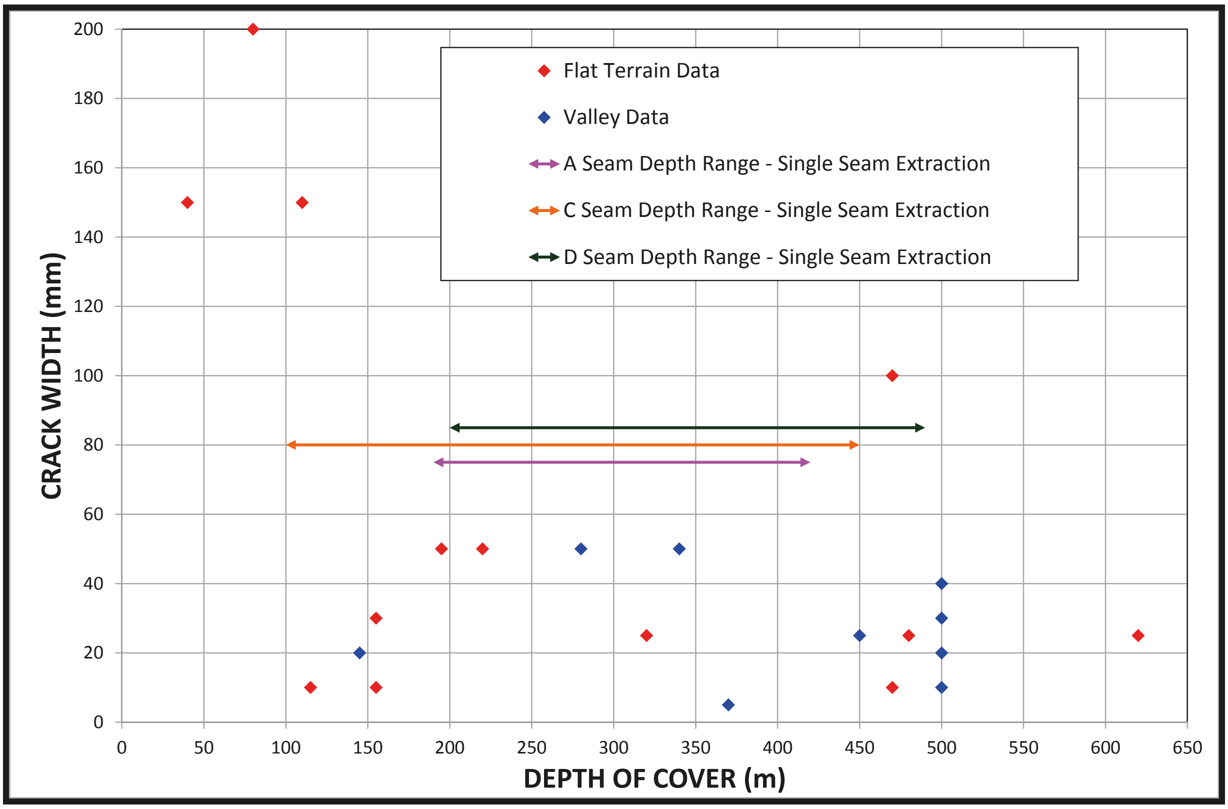


Figure 38. Crack Width vs. Depth of Cover (reproduced from MSEC, 2007).

Based on **Figure 38**, and experience at a number of operating Bowen Basin longwall mines, maximum crack widths up to 200 mm could be expected above the C Seam longwall panels in the shallower parts of the Southern Underground. The maximum crack widths predicted in single seam mining areas of the Northern Underground are 100 mm in the shallow areas, decreasing to <50 mm in the deeper areas (**Figure 38**).

5.3.1.2 Dual Seam

As well as depth of cover, ground strain is also a factor contributing to surface cracking with the largest surface crack widths predicted to occur where the strains are the highest. With reference to the predicted strains for both A and D Seam and D Seam extraction only, in **Figure 19 and Figure 21** respectively, wider cracks are expected in the dual seam extraction areas due to higher strain predictions compared to the single seam areas, at the same depth of cover.

Maximum crack widths in the shallowest areas of the dual seam section of the Northern Underground are expected to be up to 200 mm (compared to 100 mm after single seam extraction, due to the increased strains).

5.3.1.3 Type and Location of Cracks

The permanent cracks are typically located in the tensile zone around the perimeter of longwall panels. Recent surveys of permanent surface cracking at Bowen Basin longwall mines indicates that these predicted maximum subsidence crack dimensions are likely to be conservative.

Some examples of subsidence cracks from Bowen Basin longwall mines are shown **Figure 39**.

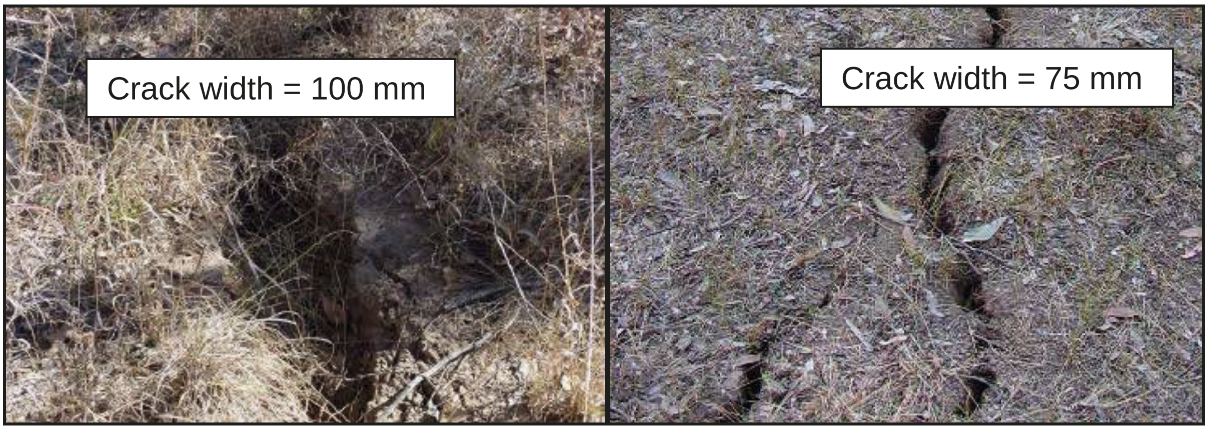


Figure 39. Examples of Subsidence Cracks.

5.3.2 Buckling and Heaving

When the near-surface strata break, the resulting blocks of rock interact and can produce localised movements. As well as surface cracking, other subsidence effects include buckling and heaving as shown in **Figure 40**.

These types of effects tend to occur less frequently than tension cracks and occur more commonly within the centre of the longwall panel area, rather than around the perimeter.

Figure 40. Heaving and Buckling.

5.4 Surface Drainage Effects

Subsidence can result in the formation of localised depressions in the surface topography that can cause ponding of surface drainage (**Figure 41**). The post-subsidence surface topography has been used to assess the potential for ponding in the EIS Surface Water Section.

Figure 41. Water Ponding over a Longwall Panel.

5.5 Subsidence Effects on Surface Geological Features

Surface geological features on the project site have been surveyed and categorised based on a reconnaissance helicopter inspection conducted by Hansen Bailey in July 2012 and a site inspection conducted by GGPL in July 2013. The site inspection involved mapping and categorisation of the surface geological features including documentation of the surface geology, feature dimensions, condition and state of weathering. The objective of this survey work was to ensure that suitable information was recorded to enable an assessment of the potential impacts of subsidence on surface geological features.

The surface geology above the Northern Underground is dominated by Darkies Range and associated erosional features (**Figure 42**). This range is dominantly composed of the Triassic Clematis Sandstone unit, which is up to 200 m thick. This unit consists predominantly of massive sandstone, with minor interbeds of siltstone and claystone.

In the low lying, flatter area to the east of Darkies Range the surface geology is dominated by Tertiary and Quaternary sediments (**Figure 43**). Localised thin pockets of Tertiary cover, <20 m thick, are also found in depressed sections on top of Darkies Range. The Tertiary in the project area consists of unconsolidated claystone and fine to medium grained weakly indurated sandstone. On the eastern side of Darkies Range, the Rewan Formation also outcrops in areas of flatter topography.

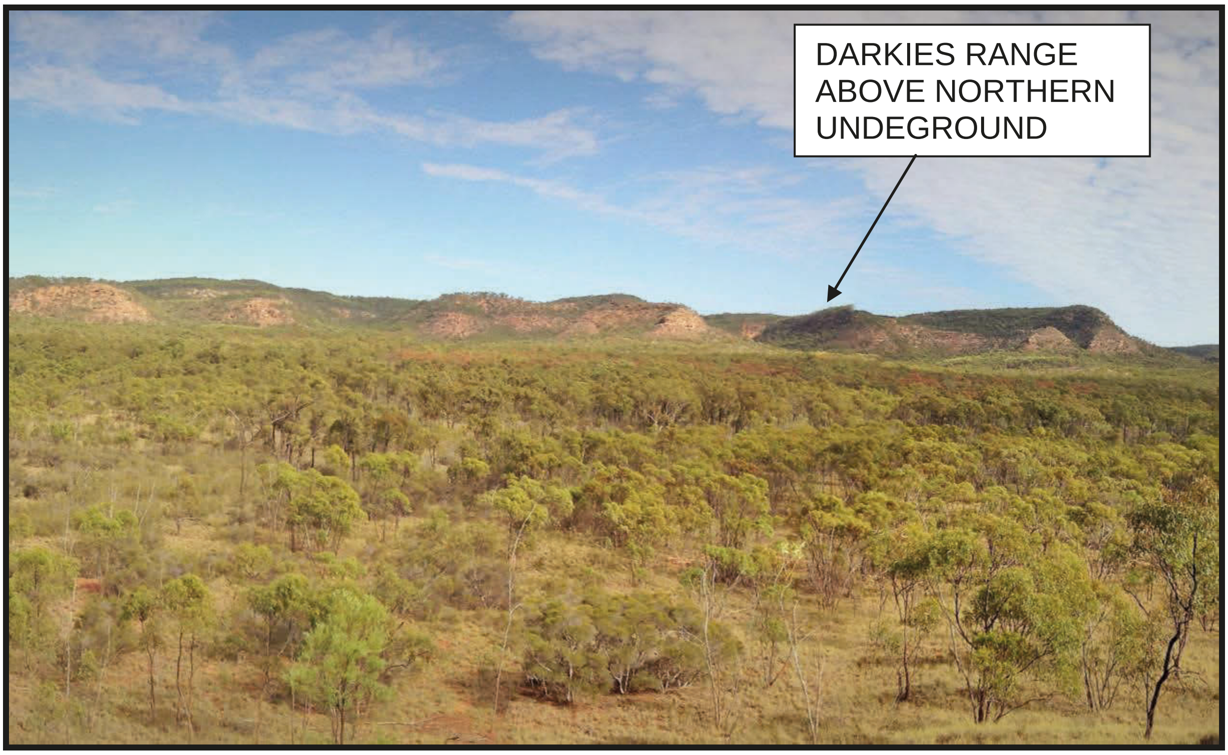


Figure 42. Darkies Range – July 2013 (Looking west).

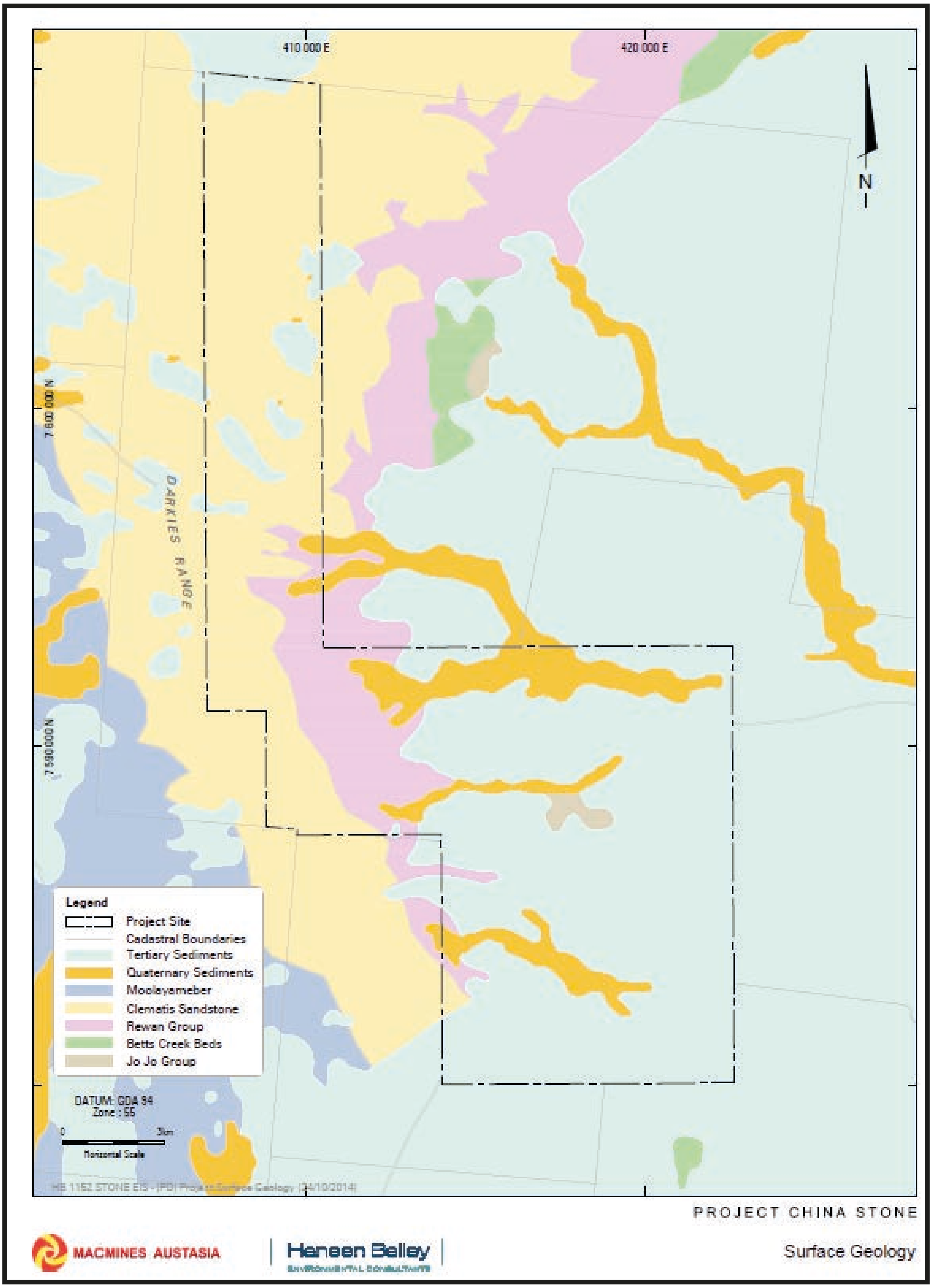


Figure 43. Surface Geology.

A range of surface features were identified including jump ups, cliffs and overhangs (**Figure 44**) and these are detailed in the following sections. As well as photographic records, field measurement of the geological joint orientations associated with features identified was also carried out. The field survey confirmed that the surface geological features on the project site are generally actively eroding due to natural weathering processes.

Figure 44. Surface Geological Features – July 2012.

The ground survey locations at which field observations were made are shown in **Figure 45** as black crosses. In addition, the photographs included in the following section to document the types of geological features are also labelled on this figure. Finally, the indicative location of the main geological features in relation to the A Seam longwall layout are identified (**Figure 45**).

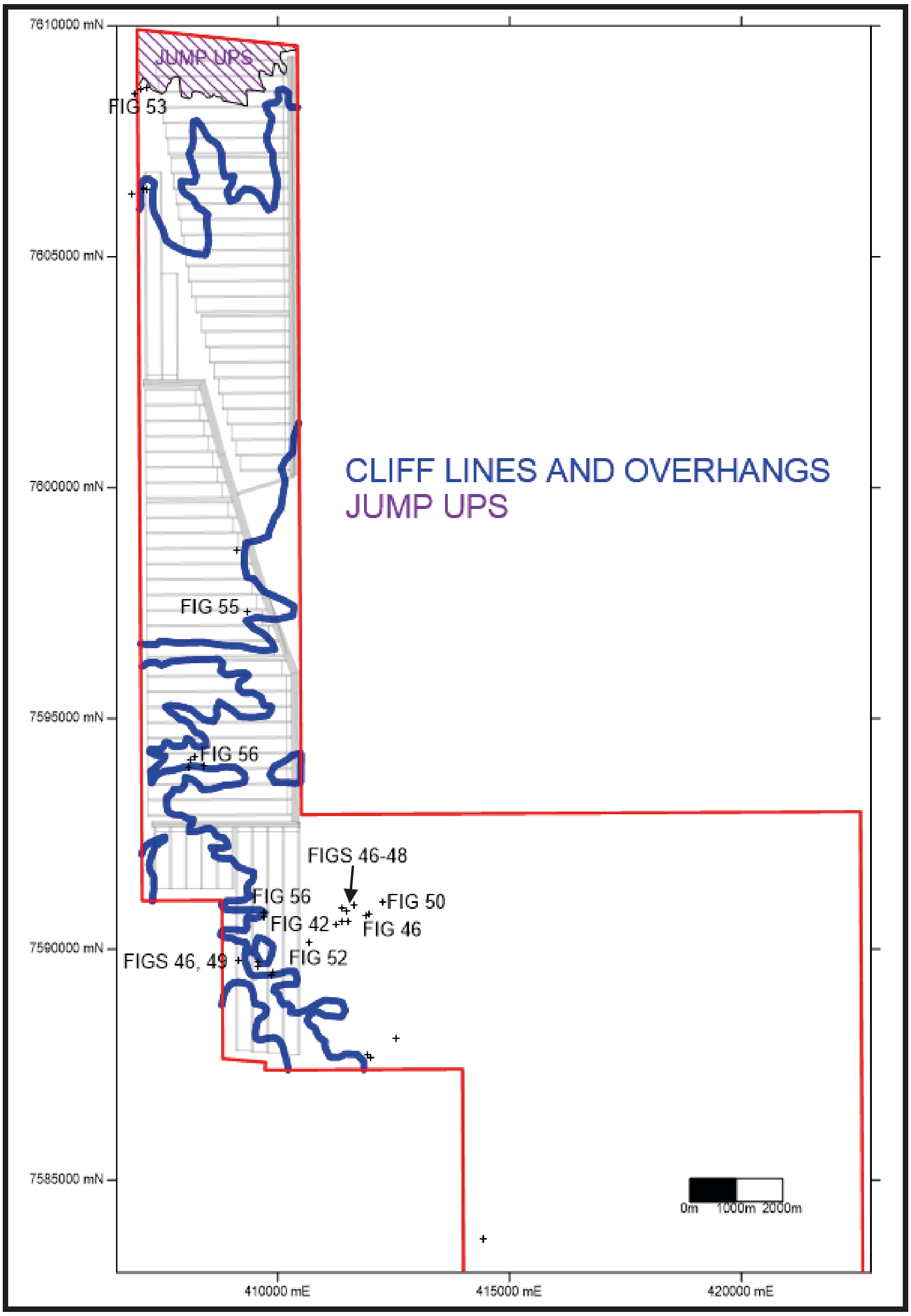


Figure 45. Location of Surface Features and Field Observation Sites.

5.5.1 Weathering Features and Failure Mechanisms

Several weathering features were noted in the outcrops around the project site in both the Tertiary, as well as the Triassic Rewan and Clematis Sandstone units. The main type of weathering appears to be the formation of overhangs due to the erosion of weaker layers (**Figure 46**). This type of weathering was noted in both the Triassic and Tertiary units.

Figure 46. Erosion of Weaker Layers.

A unique geological feature is formed in the Tertiary sediments where the less resistant material is eroded, leaving columns of more resistant rock (**Figure 47**).

Figure 47. Resistant Columns of Tertiary Strata.

Another style of weathering feature observed could best be termed an “onion” type of weathering, whereby the outer layer of sandstone weathers and peels off (**Figure 48**).

Figure 48. “Onion” Style of Weathering of Sandstone Outcrops.

The influence of jointing in the failure of large blocks was also evident in some areas (**Figure 49**).

Figure 49. Failure of Clematis Sandstone along a Joint Plane.

Natural rock falls were observed in a number of areas where an overhang has collapsed (**Figure 50**). In the extreme case, a large sandstone boulder, which had dislodged from the cliff line at the top of the range, was observed to have formed overhangs in-situ (**Figure 51**).

Figure 50. Natural Rock Falls.

Figure 51. “Mushroom” Sandstone Rock Fall Feature.

Hard ironstone bands were identified within in the Tertiary deposits (**Figure 52**). These layers form a “capping” which may reduce the weathering processes in these outcrop areas.

Figure 52. Ironstone Capping over a Sandstone Layer.

5.5.2 Feature 1 – Jump Up in the Clematis Sandstone

Where the Clematis Sandstone is exposed in the high plateau area in the northern part of the project site, distinct surface landforms were evident (**Figure 53**). This area is collectively called a jump up.

Figure 53. Jump Ups in the Clematis Sandstone.

5.5.3 Feature 2 – Overhangs

As detailed earlier, preferential weathering and erosion of softer layers forms overhangs. It should be highlighted that these overhangs are not caves and the active weathering process results in progressive collapse of overhanging rocks preventing cave formation.

These features are formed in both the Tertiary and Triassic units. Due to the strength of the strata, the overhangs typically span less than 5 m. The crumbly and bedded nature of the sandstone units, as well as the occurrence of jointing, assists the weathering process (**Figure 54**).

Figure 54. Jointing and Bedding in Sandstone.

5.5.4 Feature 3 – Cliffs

Cliff lines were observed both in the Tertiary and Triassic sediments. The maximum heights of the cliffs in Tertiary strata are in the range of 10-15 m (**Figure 55**).

Figure 55. Cliff Lines in Tertiary Strata.

The Triassic sandstone cliffs are slightly higher, with an estimated maximum height of 20 m (**Figure 56**).

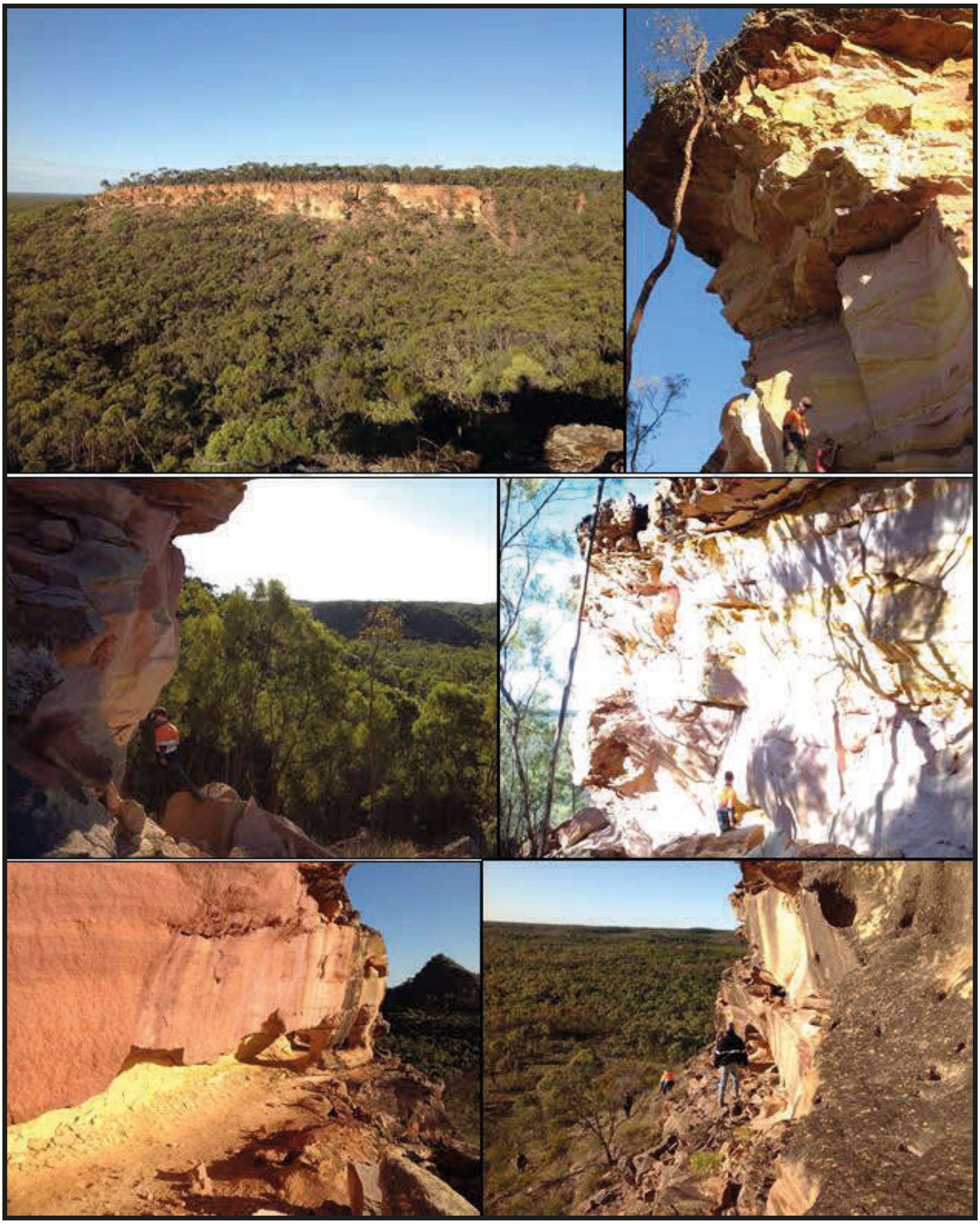


Figure 56. Sandstone Cliffs.

5.5.5 Subsidence Effects on Surface Geological Features

Experience in the Western Coalfield of NSW has found that mining directly under high sandstone cliff formations results in rock falls of varying severity. The severity is largely due to the geological and topographical structure of the overlying rock and the severity of the subsidence movements (Radloff and Mills, 2001[15]).

Radloff and Mills identified that in the Western Coalfield of NSW the visual impact is significantly reduced within 10 years of mining and many smaller rock falls are no longer visible. It should be highlighted that the cliff lines in this coalfield are larger and more topographically significant than the surface features in the project site (**Figure 57**).

Figure 57. Cliff Line – Western Coalfield, NSW (Radloff and Mills, 2001).

Other significant findings by Radloff and Mills include:

- Typically less than 20% of cliffs within the mined area experience rock falls.
- Most rock falls occur over the mined area.
- Natural rock falls have been occurring for hundreds of thousands of years as part of the natural weathering process.

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[15] Radloff, B.J. and Mills, K.W. (2001). Management of Mine Subsidence Impacts on Cliffs at Baal Bone Colliery (Western Coalfields NSW). Proceedings of the 5th Triennial Conference of Mine Subsidence, August 2001. Pp. 63-76.

A similar study by Shepherd and Sefton (2001[16]) in the Southern Coalfield of NSW also found that longwall mining below 52 rock shelters resulted in visual damage to only 5 of the shelters (<10%).

Data presented in AusIMM (2009) indicates that at overburden depths of 100 to 200 m up to an average of about 16% of cliffs undermined by longwalls are observed to experience rock falls. At depths of 500 m, this percentage reduces to <2%.

The significance rating matrix developed by Radloff and Mills is useful for determining the likely subsidence impact due to longwall mining subsidence. This matrix considers a number of factors including:

1. Physical characteristics such as cliff height and length.
2. Geological and mining characteristics such as joints, geological structure, position relative to the longwall, and the panel width/depth ratio.
3. Association with environmental features and
4. Human use aesthetics.

These factors have been considered in determining the potential effects of longwall mining on the surface features in the project site. In areas where longwall mining is not carried out the weathering processes will continue to actively erode the surface features. In the shallower longwall mining areas, it is expected that some effects may be experienced on <20% of the surface features based on monitoring in NSW. The percentage of features effected is expected to decrease in the deeper mining areas. These effects are considered an acceleration of the natural erosion process.

6 CONCLUSIONS

The key conclusions from this report include:

1. Vertical subsidence reaches a maximum of 6 m in the shallower panels in the western part of the dual seam mining area of the Northern Underground and is often >5 m. In the deeper parts of the area, the maximum subsidence reduces to 4 m. In the Southern Underground the maximum vertical subsidence is 2.7 m. Far field subsidence effects are not considered significant on the surface due to the topography of the project site.

2. The maximum tensile strains due to dual seam extraction in the Northern Underground range in magnitude up to 36 mm/m. Maximum compressive strains range up to 31 mm/m. 95% of the strains due to dual seam extraction in the Northern Underground will be less than 20 mm/m.

3. The maximum tilts developed due to dual seam extraction in the Northern Underground range up to 11% or 110 mm/m in the shallower 400 Series area. 80% of the tilts across the area will be less than 50 mm/m, which is equivalent

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[16] Shepherd, J. and Sefton, C.E. (2001). Subsidence Impacts on Sandstone Cliff Rock Shelters in the Southern Coalfield NSW). Proceedings of the 5th Triennial Conference of Mine Subsidence, August 2001. Pp. 77-85.

to a change in slope of 2.9 degrees. Higher tilts can be expected in the shallowest Southern Underground C Seam extraction areas.

4. Based on subsidence monitoring at Bowen Basin longwall mines in similar geology, greater than 97% of the maximum subsidence will typically occur within 6 weeks after longwall mining is completed, assuming an industry average retreat rate of 100 m/week.

5. There is confidence in the subsidence predictions due to the amount of information available from more than 25 years of underground mining experience in the neighbouring Bowen Basin mining area. This data has provided a sound basis to enable conservative prediction of potential environmental impacts due to subsidence effects. It is considered unlikely that there will be any significant deviations from the current predictions due to topographic, geological or geotechnical variations.

6. Based on experience in Australia and overseas, continuous subsurface subsidence cracking and resultant unrestricted inflow generally occurs to a height of about 120 m above the active longwall in single seam extraction areas, with inflow rates progressively reducing as the depth of cover increases above 120 m. As such, continuous cracking up to 120 m above the longwall panels extracted in virgin ground can be expected.

7. In the dual seam mining areas in the Northern Underground, a more conservative height of 180 m for continuous cracking above the A Seam longwall should be assumed. This 50 % increase from the initial predicted continuous cracking height should more than adequately account for the uncertainty associated with the continuous cracking height predictions and therefore provide a conservative basis for the purposes of assessing potential worst case groundwater impacts.

8. Surface subsidence cracks will develop in the proposed longwall mining areas. The areas with the highest potential for cracking are those located at the panel edges where the maximum tensile strain occurs. The widest of these cracks are predicted to extend to no more than 10-15 m below ground level. Maximum surface crack widths up to 200 mm could be expected above dual seam extraction areas of the Northern Underground and the shallower parts of the Southern Underground mining area. At greater depths, maximum crack widths <50 mm could be expected. Cracks of this size can be readily remediated.

9. In areas where longwall mining is not carried out the weathering processes will continue to actively erode the surface geological features. In the shallower longwall mining areas, it is expected that some effects may be experienced on <20% of the surface features based on monitoring in NSW. The percentage of features effected is expected to decrease in the deeper mining areas. These effects are considered an acceleration of the natural erosion process.

PROJECT CHINA STONE

Groundwater Report

Australasian
Groundwater
and Environmental
Consultants Pty Ltd
(AGE)

Report on

Project China Stone
Groundwater Report

Prepared for
Hansen Bailey

Project No. G1587 June 2015
www.ageconsultants.com.au ABN 64 080 238 642

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Project China Stone
Groundwater Report

1. Introduction

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) was commissioned by Hansen Bailey on behalf of MacMines Austasia Pty Ltd (the proponent) to complete a groundwater assessment as part of the Environmental Impact Statement (EIS) for Project China Stone (the project).

The project involves the construction and operation of a large-scale coal mine on a greenfield site in Central Queensland. The project site (the area that will ultimately form the mining leases for the project) is remote, being located approximately 270 km south of Townsville and 300 km west of Mackay at the northern end of the Galilee Basin (Figure 1). The closest townships are Charters Towers, approximately 285 km by road to the north, and Clermont, approximately 260 km by road to the south-east. The project site comprises approximately 20,000 ha of well vegetated land, with low-lying scrub in the south and east and a densely vegetated ridgeline, known as 'Darkies Range', running north to south through the western portion of the site.

The mine will produce up to approximately 55 million tonnes per annum (Mtpa) of Run of Mine (ROM) thermal coal. Coal will be mined using both open cut and underground mining methods (Figure 2). Open cut mining operations will involve multiple draglines and truck and shovel pre-stripping. Underground mining will involve up to three operating longwalls. Coal will be washed and processed on site and product coal will be transported from site by rail. It is anticipated that mine construction will commence in 2016 and the mine life will be in the order of 50 years.

The majority of the mine infrastructure will be located in the eastern portion of the project site (Figure 2). Infrastructure will include coal handling and preparation plants (CHPPs), stockpiles, conveyors, rail loop and train loading facilities, workshops, dams, tailings storage facility (TSF) and a power station. A workforce accommodation village and private airstrip will also be located in the eastern part of the project site.

The scope of this groundwater assessment is restricted to assessing activities that are proposed to be undertaken within the project site and no off-lease activities are considered in this assessment.

1.1 Scope of assessment

The project site is located on the eastern margin of the Galilee geological basin. There is a long history of exploration data relating to oil, gas, coal and water resources across the region. This data has been supplemented by recent groundwater studies for proposed coal mining projects. The local geology and hydrogeology are therefore well understood.

Darkies Range, an elevated ridge located at the western boundary of the project site, forms a regional catchment divide, and represents the easternmost extent of the Clematis Sandstone, a regional aquifer of the Great Artesian Basin (GAB). The Clematis Sandstone is underlain by the Rewan Formation, a recognised aquitard of tightly interbedded sediments. West of Darkies Range, the Clematis Sandstone and overlying sediments are known to provide sources of groundwater to watercourses, artesian springs and wetlands and Lake Buchanan. East of Darkies Range, the Clematis Sandstone is absent. In this area, coal measures and basement geology are overlain by a blanket of Tertiary sediments and more recent deposits associated with present day watercourses.

Mine development has the potential to result in depressurisation of the target coal seams and surrounding geology. Depressurisation of the local geology can potentially induce dewatering of groundwater bearing strata in the vicinity of the mine, and influence local and regional hydrogeology. The availability of groundwater resources, the reliability of water supplies, and groundwater expression in surface waters and springs can potentially be affected as a result.

This report presents an assessment of depressurisation effects arising from the development of proposed open cut and underground mining areas in the project site. A numerical model has been developed to quantify these depressurisation effects in terms of groundwater level change and groundwater inflow rates during the operations phase and post mine closure. The report provides an assessment of the potential impacts of these changes on groundwater users and the surrounding environment. The report also provides an assessment of the potential impacts of the project on groundwater quality.

1.2 Report structure

This report is structured as follows:

- Section 1: Introduction: provides an overview of the project and the assessment scope;
- Section 2: Regulatory Setting: describes the regulatory framework relating to groundwater;
- Section 3: Environmental Setting: describes the environmental setting of the project including the climate, topography, land uses and other environmental features relevant to the project;
- Section 4: Geological Setting: describes the geological setting of the project including the regional geology and local stratigraphy;
- Section 5: Investigation Methodology: describes the assessment method including the collection and analysis of hydrogeological data;
- Section 6: Hydrogeological Data: provides an interpretive summary of the hydrogeological data used in the groundwater assessment;
- Section 7: Existing Hydrogeology: describes the existing local groundwater regime for the project site and surrounding area;
- Section 8: Impact Assessment: provides a detailed description of the proposed mining activities and the potential effects on the local groundwater regime. This section also presents the predicted effects on groundwater and the assessment of resulting impacts on groundwater users and the receiving environment; and
- Section 9: Groundwater Monitoring and Management Plan: describes the proposed measures for monitoring and management of groundwater impact.

Appendix A provides a detailed description of the field investigations undertaken as part of this assessment. This appendix comprises a summary of the investigation methods and is supported by a detailed summary of bore data for on-site and private bores, and construction details and quality data for bores drilled during the field investigations.

Appendix B provides a detailed description of the numerical modelling undertaken for the project, including details of model construction, calibration and validation.

2. Regulatory framework

The following sections summarise Commonwealth and Queensland groundwater legislation and policy relevant to the project.

2.1 Commonwealth Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Commonwealth Government's principal piece of environmental legislation, and is administered by the Department of the Environment (DotE). The EPBC Act is designed to protect national environmental assets, known as Matters of National Environmental Significance (MNES), which include water resources impacted by large scale coal mining developments.

The project was declared a controlled action by the DotE on 30 October 2014. The potential impact of the project on water resources is a Controlling Provision. Approval is therefore required from the Commonwealth Government for the impacts of the project on water resources, including groundwater.

2.2 Queensland regulatory framework

2.2.1 Groundwater resources

The Queensland *Water Act 2000* (Water Act), supported by the subordinate *Water Regulation 2002*, is the primary legislation regulating groundwater resources in Queensland. The purpose of the Water Act is to advance sustainable management and efficient use of water resources by establishing a system for planning, allocation and use of water.

The water resource planning process provides a framework for the development of catchment specific Water Resource Plans (WRPs). A WRP provides a management framework for water resources in a plan area, and includes outcomes, objectives and strategies for maintaining balanced and sustainable water use in that area. Resource Operations Plans (ROPs) implement the outcomes and strategies of WRPs.

Management Areas (MAs) and their component Management Units (MUs) are defined under WRPs. Authorisation is required to take water from a regulated MA or MU for specified purposes. The specified purposes are defined under a WRP, the *Water Regulation 2002* or a local water management policy.

2.2.2 Groundwater resources of the Great Artesian Basin

The *Water Resource (Great Artesian Basin) Plan 2006* (GAB WRP) defines the availability and manages the take of water within the plan area. The plan area is defined under Schedule 1 of the GAB WRP (Figure 3). Figure 3 shows that the project site is located within the aerial extents of the GAB WRP area.

The GAB WRP applies to water in or from management units in the plan area, including artesian water, subartesian water connected to artesian water, and water in springs connected to these waters.

The GAB WRP area comprises 25 MAs. The project is located within the aerial extents of the Barcaldine North MA as defined under Schedule 2 of the GAB WRP (Figure 3). The Barcaldine North MA is divided into three MUs, with each MU comprising specific aquifers, as follows:

- MU 1 comprising the Wallumbilla Formation;
- MU 2 comprising the following aquifers:
  - Cadna-owie Formation;
  - Wyandra Sandstone Member;
  - Hooray Sandstone;
  - Westbourne Formation;
  - Adori Sandstone;
  - Birkhead Formation;
  - Ronlow Beds; and
  - Hutton Sandstone.
- MU 3 comprising the Moolayember Formation and the Clematis Sandstone.

The Clematis Sandstone occurs within the project site, and therefore the project is within Barcaldine North Management Unit 3. The Moolyamber Formation subcrops between 1 km and 7 km west of the project site, whilst the Ronlow Beds are more remote occurring at least 26 km west of the project site. The remaining aquifers are not present in the vicinity of the project site. The regional and local geology relevant to the project is detailed in Section 4. The potential project impacts on these designated aquifers has been assessed as part of this groundwater study and are discussed in Section 8.5.1.

The GAB WRP is implemented through the *Great Artesian Basin Resource Operations Plan 2007* (GAB ROP). The GAB ROP requires that the Queensland government maintain a register of the springs that support significant cultural and environmental values. The closest spring system on the register is the Doongmabulla Spring Complex, located some 22 km south of the proposed mining areas (Figure 3).

2.2.3 Groundwater licensing and reporting requirements

The taking of or interfering with groundwater is regulated under the water licensing provisions of the Water Act. The Water Act requires that a water licence is required to take or interfere with artesian groundwater anywhere in Queensland. A water licence is also required to take or interfere with sub-artesian groundwater within areas declared as management areas or declared areas under subordinate Queensland legislation. A water licence applies to direct and indirect take of groundwater.

As discussed in Section 8.5.1, the project will result in the take or interference with groundwater. The proponent will specifically require the following water licences prior to commencement of mining activities:

- A licence for take from the GAB under the GAB WRP; and
- A licence for take from the Greater Western Sub-Artesian Area under the Queensland *Water Regulation 2002*.

The administering authority for the Water Act is the Queensland Department of Natural Resources and Mines (DNRM). The proponent will be required to comply with the requirements and conditions of the water licence. The licence will specify the approved location and the source aquifer for groundwater take, along with an approved volumetric groundwater allocation. The licence will also include standard conditions that identify existing water supplies to be protected, require the proponent to make-good any pre-existing water supplies unduly affected by the project, and specify monitoring, assessment and reporting requirements. The licence will also impose requirements in relation to mine closure for the management of post mining groundwater take.

The DNRM licensing approach is designed to ensure that the total allocated groundwater take permissible in granted water licences remains within the sustainable yield of the groundwater resource. This approach ensures that individual and cumulative licensed groundwater take do not adversely impact the sustainability of the affected groundwater resource. Provided that the licensing regime does not overallocate the total take from the available groundwater resources, this regulatory approach will also ensure that the licensed take has no significant residual impact on water resources of the GAB or other aquifers.

The *Water Reform and Other Legislation Amendment Act 2014* (the Water Reform Act) was passed on 26 November 2014. The Water Reform Act includes a number of changes to the Water Act that would potentially affect the regulation of groundwater take associated with the project. Commencement of the Water Reform Act provisions has been deferred pending further review by the Queensland government.

The proponent will consult with the DNRM in relation to its obligations under the Water Act and will comply with the relevant requirements for groundwater take.

2.2.4 Groundwater values

The *Environmental Protection (Water) Policy 2009* (EPP Water) provides a framework to protect and/or enhance the suitability of Queensland waters for various beneficial uses. Groundwater resources within the project site are not scheduled under the EPP Water. Section 7 describes the groundwater setting and groundwater uses, with Section 8 describing the impacts on the aquifers and users. The environmental values relevant to the local groundwater setting and uses are outlined in Sections 6 and 7.

3. Environmental setting

This section describes the regional and local setting of the project. The location, land use, climate and topography are discussed in this section. The geological setting of the project site is discussed in Section 4.

3.1 Location

The project site is remote, being located approximately 270 km south of Townsville and 300 km west of Mackay at the northern end of the Galilee Basin (Figure 1). The closest townships are Charters Towers, approximately 285 km by road to the north, and Clermont, approximately 260 km by road to the south-east.

3.2 Land use

The project site comprises approximately 20,000 ha of well vegetated land, with low-lying scrub in the south and east and a densely vegetated ridgeline, known as ‘Darkies Range’, running north to south through the western portion of the site.

Cattle grazing on native pasture is the main land use on the project site. A number of unsealed farm access tracks and exploration tracks traverse the project site. Other minor farm infrastructure present includes livestock fences, farm dams and bores.

The predominant surrounding land use is cattle grazing. Clearing and pasture development with buffalo grass has been undertaken regionally. Limited sheep grazing for wool production is also undertaken in the region.

The only mine or mining project in the vicinity of the project site is the Carmichael Coal Mine Project. The northern boundary of the Carmichael Coal Mine Project site adjoins the southern boundary of the project site.

Other mines and mining projects are located at considerable distance from the project site. Table 1 summarises the details for each mine.

Table 1 Galilee Basin coal mines and mining projects

Mining Project	Distance from Project Site
Kevin’s Corner Coal Project	125 km
Alpha Coal Project	138 km
China First Coal Project	160 km
South Galilee Coal Project	196 km

No coal seam gas projects are currently proposed in the vicinity of the project site. The potential for cumulative groundwater impacts associated with existing and proposed mining and coal seam gas activities is discussed in Section 8.6.

3.3 Topography and drainage

At a regional scale, the landform is characterised by the remnants of a deeply weathered plateau, made up of gradually sloping plains with occasional steeper areas fronting low ranges and escarpments.

The topography of the project site is shown on Figure 4. The surface topography within the project site ranges from approximately 275 m above Australian height datum (mAHD) to 500 mAHD. Darkies Range forms a thin ridgeline in the south-western area of the site, widening to a tabletop plateau in the north-western areas. The ridgeline falls from 490 mAHD in the north, down to 395 mAHD in the southern part of the project site. The land slopes to the east of Darkies Range at a gradient of approximately 1:50, before forming the low-lying, flat to gently undulating plains that characterise the south and east of the site. The land slopes more gently to the lower lying areas west of Darkies Range.

The project site generally drains towards the east from Darkies Range, which forms a catchment divide along the western boundary of the site (Figure 4). An upper tributary of Tomahawk Creek traverses the north-eastern corner of the project site (Figure 4). The project site is located in the headwaters of the Belyando River catchment and site drainage lines are highly ephemeral, only flowing after rainfall. This contrasts with the adjacent Carmichael Coal Mine Project that is in the lower lying catchment of the Carmichael River, a major perennial river traversing the mining area. The lower elevation and shallower water table promotes the presence of springs in the vicinity of the Carmichael Coal Mine Project site.

The catchment of Lake Buchanan extends from Darkies Range to the west of the site. The project site does not lie within the Lake Buchanan catchment. Lake Buchanan lies approximately 20 km west of the project site. A minor area in the south west of the project site also drains to the Carmichael River catchment via minor drainage lines (Figure 4).

3.4 Climate

The climate is semi-arid with variable summer-dominant rainfalls. Climate data has been collected since 2003 from the Bureau of Meteorology (BoM) Carmichael weather station (036122). The Carmichael weather station (036122) is located 11 km south-west of the project site and is the closest weather station (Figure 4). The Ronlow Park (036096) and Bulliwallah (036010) weather stations are located 30 km west and 50 km east of the project site, respectively, and provide more extensive long-term datasets for comparison.

The mean daily summer temperature ranges from 23° C to 35.8° C. The mean winter temperatures range from 7.7° C to 22.5° C.

Table 2 summarises the available data for average monthly rainfall, showing an annual average rainfall rate of between 525 mm and 599 mm. The region is too far north to receive reliable winter rain and too far south to receive monsoonal wet periods typical of northern Australia. December, January and February are the wettest months indicating summer dominant rainfall.

Table 2 Mean monthly rainfall

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Bulliwallah (036010)*	110.3	118.6	75.0	38.5	24.8	25.1	21.9	13.9	12.5	28.6	51.3	83.2	599.1
Ronlow Park (036096)#	113.1	114.7	67.1	33.3	23.4	15.5	17.2	14.2	13.3	27.5	56.6	76.5	572.5
Carmichael (036122)^	127.1	122.0	55.2	32.5	14.6	23.8	15.5	11.9	21.3	17.9	61.7	65.0	525.4

Note: *values are in mm, * Data record from 1912-2014; # Data record from 1961 – 2014; ^ Data record from 2003 - 2014*

Recent rainfall years have been put into historical context using the Cumulative Rainfall Departure (CRD) method. This method is a summation of the monthly departure of rainfall from the long-term average monthly rainfall. A rising trend in the CRD plot indicates periods of above average rainfall, whilst a falling slope indicates periods when rainfall is below average. Figure 5 shows the CRD graph for Bulliwallah (036010), for the period 1972 to present.

The CRD graph indicates that the area has experienced distinct cycles of above average and below average rainfall since 1972. More recently, since 2012 the region has experienced lower than average rainfall. The Queensland Department of Agriculture, Fisheries and Forestry declared the area drought affected in September 2013.

BoM[1] mapping of average annual evaporation shows that the evaporation rate for the region is approximately 2,000 mm/yr. Annual evaporation is therefore approximately three to four times greater than the average annual rainfall.

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[1] http://www.bom.gov.au/watl/evaporation/

4. Geological setting

The geological setting has been informed by the following data sources:

- Geology logs from petroleum exploration test wells drilled from the 1960s onwards;
- Seismic survey reports for petroleum exploration;
- Geology logs from stratigraphic bores drilled by the Commonwealth Department of Mineral Resources during the 1960s;
- Geological data from private water bore drilling on properties in the region;
- Coal mining exploration drilling logs from the mid-2000s onward; and
- Coal seam gas exploration drilling logs.

The proponent engaged McElroy Bryant Geological Services (MBGS), a specialist geological modelling consultant, to develop a regional 3D geological model of the major stratigraphic units from this data.

The MBGS geological model provided the structural framework for developing a 3D numerical groundwater model by AGE. Appendix B includes a standalone report that describes the approach to the groundwater modelling in detail.

4.1 Regional geology

The regional geology comprises a sequence of three sedimentary geological basins overlying a stable tectonic basement. These basins comprise from oldest to youngest, the Drummond Basin, the Galilee Basin and the Eromanga Basin. The eastern margins of these basins outcrop in a north-south orientated arc across central Queensland and regionally dip to the west.

The project site is underlain by Galilee Basin and Drummond Basin units. The Eromanga Basin subcrops west of the project site and does not underlie the project site.

The Galilee Basin covers an area of approximately 250,000 km^2 in central Queensland. It is a sedimentary basin comprising Carboniferous to Triassic age geology. The underlying Drummond Basin comprises Devonian to Permian sediments and outcrops approximately 40 km east of the project site. The stratigraphy of each sedimentary basin is shown in Table 3.

Table 3 Summary of Regional Geology

Basin		Age		Stratigraphic Unit	Description
Eromanga Basin	Great Artesian Basin	Cretaceous/Jurassic		Ronlow Beds[1]	Quartz sandstone Regional aquifer
Galilee Basin		Triassic	Middle	Moolayember Formation[1]	Shales, mudstones, siltstones, sandstones Regional aquifer
				Clematis Sandstone[1]	Quartz sandstone Regional aquifer
			Early	Dunda Beds	Sandstone, siltstone, claystone Local aquitard - not present in project site
				Rewan Formation	Siltstone, claystone and minor fine grained sandstone Regional aquitard
		Permian	Late	Betts Creek Beds	Coal measures
			Early	Joe Joe Group	Coal measures
		Carboniferous	Late		
Drummond Basin		Carboniferous	Early	Drummond beds	Fluviatile sediments and volcanics
		Devonian	Late		

1. GAB WRP – Barcaldine North Management Unit

Regionally, a thin veneer of more recent Tertiary sediments typically overlies these basins. Figure 6 shows the subcrop of the main stratigraphic units underlying the Tertiary cover. Quaternary sediments are localised to present day drainage features. Figure 7 shows the surface geology within the project site and surrounding area.

4.2 Project Site geology

The following main stratigraphic units occur within the project site (from oldest to youngest):

- Joe Joe Group;
- Betts Creek Beds;
- Rewan Formation;
- Clematis Sandstone; and
- Tertiary sediments.

Figure 8 shows a typical stratigraphic column. Figure 9 presents cross sections through the northern, central and southern areas of the project site.

Whilst developing the geological model MBGS reviewed available literature describing the stratigraphy of the Galilee Basin. This review highlighted three main discrepancies in the published literature. Firstly, the occurrence of the Warang Sandstone and Clematis Sandstone was inconsistent in the literature and geological maps. Secondly, the Permian coal measures were inconsistently referred to as either the Betts Creek Beds, or the Colinlea Sandstone/Bandanna Formation. And lastly the location of the occurrence of the Dunda Beds was also inconsistent. MBGS sought clarification from the Department of Mines and Energy (DME) and Geological Survey of Queensland (GSQ) (Dr John McKellar at the DME and Sally Edwards at GSQ).

In the vicinity of the project site the literature states that Triassic units comprise the Moolayember Formation, Clematis Sandstone and Rewan Formation. However, the published geological maps displayed Warang Sandstone instead of Clematis Sandstone, with the literature describing Warang Sandstone as the lateral equivalent of Clematis Sandstone and Rewan Formation. Dr J McKellar indicated this was due to an error on the geological map and Warang Sandstone is actually Clematis Sandstone at the project site. The Warang Sandstone occurs further north in the Pentland area and north western Galilee Basin well beyond the project site.

Another discrepancy noted in the literature was the occurrence of varying Late Permian formations in different parts of Galilee Basin. The literature states that in southern Galilee Basin the Late Permian geology includes Bandanna Formation and Colinlea Sandstone while in the north of Galilee Basin, Betts Creek Beds occur. The Betts Creek Beds are a northern correlative of the combined Bandanna Formation and Colinlea Sandstone to the south. It is not clear in the literature where the transition is between each Formation. MBGS discussions with Dr J McKellar and S. Edwards indicated that the exact boundary between each formation is unknown due to sparse drilling data in the region. MBGS set the boundary in the geological model at approximately 24^{o}S, which is level with the northern extent of Springsure shelf. The southern extent of the project site is well north of this boundary and the Betts Creek Beds is the coal bearing formation proposed for mining.

The Carmichael Coal Mine Project EIS identified the presence of Dunda Beds at the Carmichael Coal Mine Project site (GHD, 2013). The available literature describes the Dunda Beds as occurring in the east of the Galilee Basin, but not being laterally consistent across the basin (Van Heeswijck 2006). The DME geological maps confirm occurrence of the Dunda Beds approximately 20 km south east of the project site. Extensive investigation work within the project site confirmed that the Dunda Beds does not occur between the Clematis Sandstone and Rewan Formation. There is a transition from Rewan Formation outcrops to Dunda Beds outcrops between Buchanan and Galilee mapping sheets south of the project site.

The following sections describe the stratigraphic units that occur within the project site.

4.2.1 Joe Joe Group

The Carboniferous Joe Joe Group comprises conglomerate, lithic sandstone, siltstone, minor mudstone and coal. The Joe Joe Group is the base unit of the Galilee Basin and underlies the Betts Creek Beds, which contain the target coal seams for the project. The Joe Joe Group subcrops to the east of the project site under the Tertiary sediments, and therefore is not exposed at the surface in the project site.

4.2.2 Betts Creek Beds

The Late Permian Betts Creek Beds comprises interbedded sandstone, siltstone, mudstone, shale and coal. The Betts Creek Beds are up to 180 m thick and are typically consistent regionally throughout the northern Galilee Basin. This unit is an equivalent of the Colinlea Sandstone and Bandana Formation units.

The Betts Creek Beds contains seven coal seams, named sequentially from A to G with increasing depth. Typically, the A Seam is approximately 30 m below the upper boundary of this unit. Cumulative thickness of coal within the Betts Creek Beds is approximately 35 m, with the thickest coal horizon being the A and B Seams.

4.2.3 Rewan Formation

The Rewan Formation is a thinly interbedded sequence of siltstone, claystone and fine grained sandstone. This forms a hydraulically tight unit that is a recognised regional aquitard. This unit is an equivalent of the Dunda Beds unit. The Rewan Formation outcrops along the eastern margins of Darkies Range and in the project site unconformably overlies the Betts Creek Beds.

4.2.4 Clematis Sandstone

The Clematis Sandstone is predominantly a massive sandstone unit, with minor interbeds of siltstone and claystone. This unit is a recognised regional aquifer of the GAB. The formation outcrops as the western slopes of Darkies Range and is up to 200 m thick, thinning to the east due to erosion. This unit is deeply weathered along Darkies Range and in this area weathering has promoted vertical flow of groundwater to depths of over 100m. The unit weathers to pink and red and is naturally white when fresh. Prominent red laterite horizons occur on Darkies Range.

The Clematis Sandstone unconformably overlies the Rewan Formation. Along the eastern slopes of Darkies Range, localised erosion of the Clematis Sandstone has exposed the underlying Rewan Formation and Betts Creek Beds.

4.2.5 Tertiary and Quaternary Sediments

The Tertiary sediments comprise fine to coarse grained, weakly indurated sandstone and siltstone with lesser claystone. This unit is a highly weathered detrital deposit sometimes with a lateritic red colouring and covers much of the low-lying areas either side of Darkies Range. The Tertiary sediments either side of the Darkies Range vary in thickness from 10 m to 77 m, but are typically between 30 m and 60 m. Figure 7 shows the extent of the Tertiary sediments. Whilst geological maps show some localised deposits of Tertiary sediments on the plateaus of Darkies Range, drilling has confirmed they are typically absent from these elevated areas.

Regional geological mapping indicates the presence of fluvial sediments associated with present day drainage features (Figure 7). The distribution of these sediments in the vicinity of the project site was further investigated through targeted groundwater drilling and stream geomorphology assessments. These assessments are discussed in Section 5.3.1 of this report and the EIS Surface Water section, respectively.

These studies confirmed that the minor drainage features and overland flowpaths present within the project site and downstream catchment are characterised by rock channels or exposed Tertiary materials. Extensive, deep alluvial deposits and associated shallow groundwater are therefore absent from the project site and surrounding area. Fluvial sediments present in the vicinity of the project site are limited to thin (less than 1 m) patches of mud and gravel that dry quickly following flow events.

This contrasts with the extensive alluvial deposits associated with the regionally significant Belyando and Carmichael River systems. These alluvial deposits are recharged by direct rainfall to large catchments and seepage from major rivers during periods of surface flow. These alluvial deposits are known to support a perennial water table and exhibit high yields and permeability. The Belyando River alluvium is located 50 km downstream of the project site and Carmichael River alluvium is located in a separate catchment from the project site.

4.3 Geological structure

Historical exploration for petroleum has not detected any large or extensive faults within the region of the Galilee Basin surrounding the project site. At the project site exploration drilling detected one normal fault of limited extent running through the northern portion of the project site (Figure 6). The fault is aligned north-northwest to south-southeast within the Triassic and Permian sediments. Figure 6 and Figure 7 show the fault alignment and extents. Geological data indicates the fault opens and closes at the southern and northern extremities with 100 m maximum displacement in the centre. The fault breaks the continuity of the Clematis Sandstone and on the downthrown eastern side of the fault, places this unit in direct contact with the Rewan Formation that lies on the western side of the fault. Section 7.3 discusses the hydrogeological behaviour of the fault in detail.

5. Investigation methodology

This section outlines the methodology adopted for the collection of hydrogeological data to inform the groundwater assessment. A detailed description of the field investigation methods and findings is provided in Appendix A. Groundwater data including field investigations results from the project site and the surrounding area are presented in Section 6.

5.1 Overview of methodology

A detailed background study was undertaken to develop an understanding of the hydrogeological setting of the project. This included:

- Review of regional and local groundwater studies and other relevant technical reports, including publicly available reports prepared in relation to the Carmichael Coal Mine Project;
- Review and interpretation of regional and local geological data, including an extensive exploration and geological database collected by the proponent;
- Review of hydrogeological data held on the DNRM Groundwater Database (GWDB) for existing private water bores; and
- An extensive field investigation drilling and testing program to refine the understanding of the groundwater regime at the project site. This included:
    - Targeted drilling and installation of groundwater monitoring bores and vibrating wire piezometers (VWP);
    - Completion of field tests to determine local hydrogeological characteristics;
    - Completion of a census of unregistered private bores to confirm groundwater use and quality in the vicinity of the project; and
    - Collection of water samples from monitoring and private bores to characterise groundwater quality.

All relevant hydrogeological data was compiled and analysed to conceptualise the groundwater regime in detail. A numerical groundwater model was developed to predict the scale and extent of any changes to the groundwater regime throughout the mine operations phase and post closure. These predictions were used to assess the potential project and cumulative impacts on groundwater resources and levels, water quality, and groundwater users. Appropriate groundwater monitoring and management strategies were developed to address any potential for significant adverse impacts and validate the findings of the assessment.

5.2 Carmichael Coal Mine Project field investigations

The Carmichael Coal Mine Project site adjoins the southern boundary of the project site. The geological setting of the Carmichael Coal Mine Project and the project are therefore comparable, and where key stratigraphic units are present on each site these can be considered equivalent.

Extensive field investigations were completed between 2011 and 2013 at the Carmichael Coal Mine Project site to support the EIS and supplementary reports (GHD 2013). These investigations included the installation of a monitoring bore network, collection of permeability data in all major stratigraphic units, water quality sampling and analysis, and a bore census of surrounding private bores.

The groundwater monitoring network comprised 64 standpipe piezometers located at 35 sites and a further 24 nested VWPs at eight sites. Figure 10 shows the locations of the monitoring sites at the Carmichael Coal Mine Project.

A total of 123 water quality samples were collected over three sampling rounds between October 2011 and May 2013. Samples were analysed for major cations and anions, trace metals, and nutrients.

Hydraulic permeability was measured in each of the major stratigraphic units within the Carmichael Coal Mine Project site as shown in Table 4. Methods used to collect the data included falling head and rising head tests on monitoring bores, packer tests on open holes, and 48 hour constant rate pumping tests on selected bores installed in the coal seams.

Table 4 Permeability testing - Carmichael Coal Mine Project

Stratigraphic Unit	Falling / Rising Head Tests	Packer Tests	Pumping Tests
Quaternary Sediments	6	-	-
Tertiary Sediments	6	-	-
Clematis Sandstone	2	-	-
Dunda Beds	6	-	-
Rewan Formation	12	6	-
Permian Overburden (Betts Creek Beds above A Seam)	9	6	-
A / B Seam	2	9	1
Permian Interburden (Betts Creek Beds between coal seams)	7	17	-
D Seam	1	6	2
Total	**51**	**44**	**3**

A number of permeability tests were undertaken on the Quaternary and Tertiary Sediments occurring at the Carmichael Coal Mine Project site. As discussed previously, the superficial geology of the project site differs significantly from that of the Carmichael Coal Mine Project. The project is located within the headwaters of a minor sub-catchment where significant Quaternary Sediments are not present and the Tertiary sediments are largely dry.

A census of private bores completed for the Carmichael Coal Mine Project identified 26 registered bores within 10 km of the Carmichael Coal Mine Project site boundary. Of the 26 identified in the DNRM database, only seven could be located. Section 6.4 discusses the results from the Carmichael Coal Mine Project bore census in conjunction with the results from the project site bore census. Figure 11 shows the landholder stations and private bores.

5.3 Project site field investigations

An integrated geological exploration and groundwater field investigation program was developed for the project site. This program was intended to maximise the use of each exploration drilling location for collection of hydrogeological data relevant to the groundwater assessment.

Based upon the project setting, regulatory context and understanding of the local geology, the key objectives of the integrated field investigation program were to:

- Collect detailed site-specific geological data to refine the understanding of the project site geology, including confirmation of the extents of key hydrogeological units across the project site;
- Collect detailed drilling logs and core samples from all stratigraphic units to accurately characterise the units that are likely to govern the local groundwater regime;
- Target drilling depth and distribution to stratigraphic units that are known GAB sediments or confining units;
- Target stratigraphic units overlying proposed longwall mining areas;
- Extend geological drilling depths to target stratigraphic units below the target coal seams to provide information on the composition, distribution and hydraulic properties of the underlying materials;
- Extend geological drilling depths as far as practical to maximise the groundwater intersected across the project site;
- Target drilling layouts to proposed mining waste storage facilities; and
- Target drilling to the fault in the north of the project site to refine the understanding of fault alignment and displacement.

To maximise the rigour of the groundwater assessment, the extensive field investigations undertaken at the project site have been used in association with previous investigations including drilling associated with the adjoining Carmichael Coal Mine Project. Section 5.2 describes relevant field investigations undertaken within the vicinity of the project site.

Field investigations into the hydrogeology of the project site were undertaken between December 2012 and October 2013 and included:

- drilling and constructing a groundwater monitoring network;
- post-drilling measurements of groundwater quality and hydraulic properties including falling head and packer testing; and
- a census of private bores to confirm the extent of existing groundwater use and surface expression of groundwater.

Appendix A provides more detail on the methodology employed for these field investigations.

5.3.1 Groundwater monitoring network

A total of 31 groundwater monitoring bores and 12 VWP in four holes were installed on 23 sites across the project site between December 2012 and August 2013. Appendix A summarises the field investigations and contains the composite bore construction and stratigraphy logs for each site.

5.3.2 In-situ permeability testing

As a part of the investigation, 18 falling head tests were completed on 16 bores. The testing was designed to evaluate the hydraulic conductivity of material surrounding the bore screen.

A total of 68 packer tests were completed in eight HQ[2] core holes during the investigation targeting the all the major coal seams along with the Rewan Formation and the Permian interburden and overburden. The Clematis Sandstone was commonly dry and relatively weak, and therefore required casing to stabilise the borehole during drilling. It was therefore not practical to test this unit with the packer apparatus. Falling head tests were instead undertaken in monitoring bores where saturated Clematis Sandstone was present.

Packer tests consisted of isolating a section of a bore hole with inflatable packers so tests could be conducted on a discrete zone or feature (e.g. a coal seam). Figure 12 shows the sites where packer testing was undertaken. The packer testing intervals were selected to ensure representative data was collected for each of the major Permian and Triassic units.

Appendix A summarises the falling head and packer test details. Section 6.2 presents the results from the in-situ permeability testing in the project site.

5.3.3 Water quality sampling

A total of 38 groundwater samples were collected over two rounds of sampling from 21 groundwater monitoring bores between March 2013 and April 2014. The water samples were submitted to ALS Environmental Laboratories (ALS) for analysis. ALS is National Association of Testing Authorities (NATA) accredited. The field pH and electrical conductivity (EC) was measured during each sampling event.

Appendix A summarises the water quality sampling method and presents the suite of parameters analysed. Section 6.3 presents the water quality results.

5.3.4 Bore census

A census of private bores was carried out by AGE between December 2012 and June 2013 at the project site and surrounding properties. The bore census was completed to identify the condition and use of all registered and unregistered private bores surrounding the project site that could potentially be impacted by the project. In addition, data from a bore census conducted by GHD as part of the groundwater investigation for Carmichael Coal Mine Project was also utilised.

Section 6.4 presents a summary of the bore census results. Appendix A presents the bore census results in detail.

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[2] HQ is a standard core barrel size of 96mm outside diameter, producing a rock core of 63.5mm diameter

6. Hydrogeological data

This section presents an overview of the hydrogeological data collected as part of the field investigation programs at the project site and surrounding area, including data collected from the Carmichael Coal Mine Project site, where relevant to the current assessment.

6.1 Groundwater distribution and flow

Water level readings provide useful information on the vertical and lateral hydraulic gradients, and can also be used to interpret hydraulic conditions such as relative permeability. Key trends demonstrated by water level data are as follows:

- a downward vertical gradient on Darkies Range that indicates a groundwater recharge area;
- stable groundwater levels during the monitoring period indicated limited recharge and discharge;
- the Tertiary Sediments are largely dry and unsaturated in the project site due to the topography and elevation of the project site relative to the surrounding area. A water table forms in these sediments as the elevation drops to the south-east. The water table encroaches on the extreme south-eastern portion of the project site (Figure 13);
- the Clematis Sandstone is largely dry and unsaturated in the project site due to its location at the outer margins of the formation and the significant elevation of the formation within the project site relative to the surrounding topography;
- on Darkies Range the potentiometric surface is generally within the Rewan Formation beneath the Clematis Sandstone; and
- the potentiometric surface measured within the Rewan Formation is some 10 m higher than the potentiometric levels measured in the underlying Betts Creek Beds, indicating the Rewan Formation has a low permeability retarding downward movement of groundwater to the underlying Permian stratigraphy. This confirms that the Rewan Formation behaves as an aquitard.

Figure 14 presents hydrographs for VWP1, VWP2, VWP3 and VWP4. These VWPs are located in the west of the project site on Darkies Range. The hydrographs show the downward hydraulic gradient present in the Darkies Range area from the shallower to the deeper formations, confirming that Darkies Range is a groundwater recharge area, and also that the Rewan Formation retards the flow of groundwater. It is important to emphasise that whilst water samples and water levels have been measured within the Rewan Formation and the Permian Sediments, it does not mean these units form aquifers. When boreholes were drilled into these formations, below the regional potentiometric surface, they were very slow to fill with water confirming low permeability, inconsistent with aquifer characteristics.

Figure 15 presents groundwater level hydrographs recorded in groundwater monitoring bores. Only bores with sufficient data to allow meaningful interpretation of water levels over time were included. The groundwater level data, logged at six hourly intervals, indicate that groundwater levels were relatively static over the monitoring period.

The hydrographs show that piezometric levels within the Triassic Rewan Formation are generally between 310 mAHD to 330 mAHD across the project site, while piezometric levels within the Permian stratigraphy ranges between 280 mAHD and 310 mAHD. Although the water levels are largely controlled by topography, the higher levels in the Rewan compared to the Permian is further evidence of the downward gradient observed in the vibrating wire piezometers.

The bores logs presented in Appendix A show the Tertiary Sediments and Clematis Sandstone are generally dry and unsaturated across the project site.

Figure 16 shows the regional groundwater levels spatially and the interpolated equipotential contours. Spatially, the groundwater levels appear to be influenced by the local geomorphology. In the vicinity of the project site, groundwater levels are dominated by the presence of Darkies Range. Groundwater levels generally flow in an east to south-easterly direction on the eastern side of Darkies Range. To the west of Darkies Range groundwater generally flows in a west to south-westerly direction.

As discussed previously much of the project site is elevated in the catchment headwaters and therefore the Tertiary Sediments are largely dry, and only saturated in lower lying areas of the project site. Figure 13 shows where the Tertiary Sediments are saturated, the saturated thickness in the base of the unit and the depth to the potentiometric surface. It confirms that the Tertiary sediments are largely dry where mining is proposed, only becoming saturated in the eastern lower lying portion of the project site.

6.2 Hydraulic conductivity testing

Figure 17 graphically presents the results of 114 packer tests and 40 rising / falling head test results from both the project site and the Carmichael Coal Mine Project. Key trends demonstrated by these data include:

- the Clematis Sandstone shows a greater hydraulic conductivity than the other formations in the vicinity of the project and is relatively permeable;
- the Quaternary alluvium also reported relatively permeable results but is not present in the Project site; and
- the Rewan Formation and the Betts Creek Beds recorded the lowest hydraulic conductivity indicating generally low permeability.

6.3 Groundwater quality

Groundwater quality data provides useful information on the beneficial use of the groundwater associated with the major stratigraphic units. Appendix A presents the water quality data collected during the project site investigation.

Key trends demonstrated by the water quality data include:

- groundwater from all the major stratigraphic units is of suitable quality for stock watering. This is currently the main groundwater use in the region;
- some groundwater samples were suitable quality for irrigation, although limited bore yields preclude this groundwater use in the project site. This groundwater use is not known to occur within the region; and
- groundwater from all the major stratigraphic units is typically unsuitable for use as drinking water supply. This groundwater use is not known to occur within the region.

Salinity is a key constraint to water management and groundwater use, and can be described by total dissolved solid (TDS) concentrations. TDS concentrations are commonly classified on a scale ranging from fresh to extremely saline. Figure 18 shows a histogram of the available TDS data using this classification convention. The distribution of TDS values shows that groundwater quality across all geological units varies from fresh to moderately saline.

Salinity and dissolved metal and metalloid concentrations were all below the Australian and New Zealand Environment and Conservation Council (ANZECC, 2000) guideline levels for livestock drinking water.

To assess the suitability of groundwater for irrigation use, a number of factors must be considered. These include bore yields, water salinity, soil properties, plant salt tolerance and climate. Whilst some groundwater bores yielded recorded relatively fresh water, the general lack of irrigation in the region suggests other factors prevent the use of water for irrigation.

6.4 Bore locations and groundwater use

As discussed within Section 5.3.4, the bore census collated data from all private bores within the vicinity of the project site and beyond. Private bores comprise DNRM registered bores, unregistered landholder bores and bores identified in the Carmichael Coal Mine Project EIS. Data collected from these private bores through the bore census was incorporated into the wider field investigation dataset and informed the understanding of the hydrogeological setting and groundwater modelling (described in Section 7 and Appendix A of this report, respectively). The full list of private bores within the area of the groundwater model is included in Appendix A.

Private bores were also used to assess the current groundwater use within the vicinity of the project site. A total of 52 private bores were identified within 20 km of the project site.

Figure 11 shows the location of the private bores relative to the project site and geological unit each bore is expected to draw water from. Table 5 provides a summary of the number of bores in each geological unit.

Table 5 Summary of Private Bores by Stratigraphic Unit within 20 km of Project Site

Screened unit	Number of private bores[1]
Alluvium	2
Tertiary Sediments	17
Moolayember Formation	8
Clematis Sandstone	8
Rewan Formation	3
Betts Creek Beds/Joe Joe Group	14
Total	**52**

1. Includes private bores where response zones interpolated from detailed geological model

The bore census identified the primary use for private bores is for stock water supply. Generally, bores which are located to the west of the project site are screened within the Moolayember Formation and Clematis Sandstone. Private bores to the east of the project site are generally screened within the Tertiary Sediments, where a water table is present on properties east of the project site. For some of the private bores construction details are limited. Where the bore response zone is unclear, the geological model was using to determine the most appropriate surfaces / units based on bore depth.

7. Existing hydrogeology

This section details the existing hydrogeology of the project site and surrounding area, by describing the hydrogeological properties of each geological unit based on the data collected as discussed in Section 5.

The following stratigraphic units are identified as influencing the existing groundwater regime within the project site and immediate surrounds:

- Betts Creek Beds;
- Rewan Formation;
- Clematis Sandstone; and
- Tertiary sediments.

In addition, the Moolayember Formation, whilst not located within the project site and immediate surrounds, is a GAB unit and influences the wider regional groundwater regime. This unit is discussed for completeness. Other regional stratigraphic units have negligible bearing on this assessment.

The following sections discuss the groundwater distribution and quality, hydraulic characteristics, and groundwater use associated with each of these hydrogeological units.

7.1 Betts Creek Beds

7.1.1 Distribution

The Permian Betts Creek Beds sub-crop under the Tertiary sediment cover immediately east of Darkies Range and dip gently towards the west. The sub-cropping Betts Creek Beds are deeply weathered and the coal seams are typically absent within this weathered profile. As the seams dip under the Darkies Range the depth increases to between approximately 200 m and 450 m at the western extent of the project site. Figure 19 shows structure contours for the base of the Betts Creek Beds and the depth from the ground surface to the base.

7.1.2 Hydrogeological parameters

Testing from the project site indicates the Permian Betts Creek Beds form a sequence typical of coal measures, where the coal seams act as a low to moderately permeable aquifer system, confined between low permeability interburden that acts as discrete aquitards between the coal seams.

Hydraulic testing shows that the interburden, which comprises siltstones and sandstones, has a low permeability of between 1.1×10^{-4} m/day and 1.9×10^{-2} m/day. The coal seams are more permeable due to cleat networks that more readily transmit water, with hydraulic conductivity of the seams ranging between 1.5×10^{-3} m/day and 2.3×10^{-1} m/day.

7.1.3 Recharge, flow and discharge

Rainfall recharge to the Betts Creek Beds is very low. VWP installed through Darkies Range indicate a downward hydraulic gradient, and therefore some recharge through the elevated topography into the underlying Betts Creek Beds. However, the amount of recharge is limited by the layered low permeability interburden and the nature of the overlying Rewan Formation that retards flow vertically. Higher recharge is likely to occur where the coal seams subcrop, however again the recharge rate will be low due to the weathered clayey nature of the Permian Sediments underlying the Tertiary cover. Runoff from Darkies Range that collects in the drainage lines at the break of slope is also considered an area where recharge to the Permian Betts Creek Beds occurs, although the volumes will be limited by the small area of this zone. The relatively deep water levels also support a low rainfall recharge rate to the Betts Creek Beds.

Measurements of groundwater levels within the monitoring network indicates groundwater flow is a subdued reflection of the typography and surface water catchments, i.e. from topographically elevated areas to lower lying parts of the landscape. Darkies Range acts as a groundwater divide, with groundwater flowing west towards Lake Buchanan and east following the surface water catchments. The southern part of the project site has a south-easterly groundwater flow direction, again following topography (Figure 4).

Groundwater recharge is considered low, and therefore it follows discharge volumes are also very low. Slow discharge into overlying formations is the expected main discharge mechanism.

7.1.4 Water quality

Groundwater samples collected from the monitoring bore network installed at the project site indicate groundwater quality varies depending on depth and sample location. Water samples collected from the coal seams recorded slightly brackish to brackish groundwater, whilst fresh to slightly brackish samples were obtained from bores screening the interburden. Fresher groundwater potentially occurs at the break of slope zone where recharge is enhanced.

7.1.5 Yields and use

The groundwater database and the bore census findings show that 14 private bores intersect the Betts Creek Beds / Joe Joe Group within 20 km of the project site (Figure 11). All of the private bores are located east of Darkies Range on the Hyde Park, Dooyne, Moray Downs and Laboona properties. The bores are between 4 m and 120 m in depth and generally record fresh to slightly brackish water quality, with low yields of between 1.5 L/s and 4 L/s. Whilst this suggests the Permian units form a water bearing system, these bores represent the boreholes that successfully intersected a water supply. Bores that failed to encounter sufficient water are rarely notified and listed on the GWDB. Therefore, the groundwater database represents private bores that were successfully drilled in more fractured areas, and likely represent an upper bound in terms of water supply rates from the Betts Creek Beds. The true average yield is expected to be much lower than suggested by the GWDB.

7.2 Rewan Formation

7.2.1 Distribution

The Rewan Formation is a thinly interbedded sequence of siltstone, claystone and minor fine grained sandstone. The Rewan Formation outcrops along the eastern margin of Darkies Range and unconformably overlies the Permian Betts Creek Beds. Figure 20 shows structure contours for the base of the Triassic Rewan Formation and the depth from the ground surface to the base.

The potentiometric surface is relatively deep under Darkies Range where groundwater levels within the Rewan Formation can be more than 100 m below the surface.

7.2.2 Hydrogeological parameters

The Rewan Formation is considered a regional aquitard and acts as a confining unit beneath the GAB aquifers.

This unit is characterised by low primary porosity and as a result, groundwater flow is controlled by local fracture sets. Where fractures are intersected testing shows slightly higher permeability, and conversely, where no fractures are intersected testing shows lower permeability associated with the primary porosity. At a local scale, this is reflected in the measured hydraulic conductivity range of between 5.3 x 10^{-4} m/day and 1.6 x 10^{-1} m/day.

Bulk permeability of this unit is constrained by connection between any localised fractures (i.e. groundwater must flow through low permeability areas reducing the flow rates). This means that at the regional scale the representative average hydraulic conductivity is expected to be towards the lower end of the values measured by field testing. This is reflected in the regional interpretation of this unit as an aquitard.

7.2.3 Recharge, flow and discharge

The recharge / discharge mechanisms and flow directions in the Rewan Formation are equivalent to those of the Betts Creek Beds. Recharge is very low occurring via diffuse rainfall infiltrating through Darkies Range, at the edge of the range where runoff concentrates and via seepage through the Tertiary sediments. The potentiometric surface and flow directions reflect the surface topography and catchments with limited discharge into overlying formations. The deep unsaturated zone running along Darkies Range again confirms the relatively low recharge rates.

7.2.4 Water quality

Groundwater samples collected from monitoring bores installed within Darkies Range within the Rewan Formation indicate a variable water quality from fresh to moderately saline.

7.2.5 Yields and use

There are potentially three private bores that may intersect the Rewan Formation within 20 km of the project site (Figure 11). All of the bores are located on Moray Downs, a property purchased by the proponent of the Carmichael Coal Mine Project. The bores are drilled to between 55 m and 105 m in depth, and whilst no data is available on yields they are expected to be low given the low permeability of the sediments that form the Rewan Formation.

7.3 Triassic Clematis Sandstone

7.3.1 Distribution

The Clematis Sandstone outcrops or sub-crops along the north-south aligned Darkies Range. In these areas the water table is deep, in places exceeding 100 m below surface and the Clematis Sandstone is therefore typically dry and unsaturated. The exception is on the eastern side of the fault that bisects the Northern Underground of the project site. Figure 21 shows structure contours for the base of the Clematis Sandstone and the depth from the ground surface to the base of this unit. To the east of the fault, a thin wedge of Clematis Sandstone sediments are below the water table. In this area the saturated thickness of the Clematis Sandstone reaches 50 m, gradually reducing to the east as the base of the unit rises above the water table. Figure 22 shows the saturated thickness of the unit, highlighting the wedge of sandstone saturated along the fault zone. This represents the potentiometric surface subtracted from the base of the Clematis Sandstone. Down-dip the unit becomes confined by the overlying Moolayember Formation and beyond this point the contours represent the pressure head above the base of the aquifer.

7.3.2 Hydrogeological parameters

As Figure 22 shows, the largely unsaturated nature of the Clematis Sandstone within the project site has limited the amount of testing of saturated hydraulic conductivity that could be undertaken within this unit. Two measurements of hydraulic conductivity within the Clematis Sandstone at the project site recorded hydraulic conductivity measurements of 5 x 10^{-3} m/day and 9 x 10^{-2} m/day, indicating moderate to low permeability. These hydraulic conductivities reflect the significant depth of weathering occurring along the Darkies Range that results in the Clematis Sandstone being clay bound in this area.

7.3.3 Recharge, flow and discharge

The recharge / discharge mechanisms and flow directions in the Clematis Sandstone are similar to those describe above for the underlying Rewan Formation and Betts Creek Beds. The generally dry nature of the Clematis Sandstone and relatively deep water table within the vicinity of Darkies Range indicates low recharge rates. Groundwater flows reflect surface topography and catchments, with limited discharge into overlying formations. Lake Buchanan is also an inferred indirect discharge zone for the Clematis Sandstone groundwater via the overlying Moolayember Formation. The salt pans that surround Lake Buchanan and the saline water quality indicates volumes of groundwater discharging to the lake are low and readily removed by evaporation[3].

7.3.4 Water quality

Groundwater samples collected from the Clematis Sandstone indicate a fresh to slightly brackish water quality.

7.3.5 Yield and use

There are eight private bores that intersect the Clematis Sandstone within 20 km of the project site (Figure 11). Five of the bores are south of the project site with two of these on the Moray Downs property, two on the Carmichael property and one on Doongmabulla property. One bore is north-west of the project site on the Yarrowmere property, and two relatively new bores drilled in 2013 are present to the west on the Moonoomoo property. The bores are generally used for stock water supply, with the Wild Bore on the Carmichael property used for domestic supply (camp).

The yields from the Clematis Sandstone bores are moderate and range from 0.5 L/sec to 6 L/sec, indicating this unit forms the most productive aquifer within the vicinity of the project site.

The bore on the Doongmabulla property (RN16895,) has been documented as intersecting the Moolayember Formation in the GWDB. However, review of the lithological logs and depth of the bores indicates it likely intersects the Clematis Sandstone. The modelling described in latter sections of this report assumes this bores is in the Clematis Sandstone aquifer, to ensure a conservative approach to potential groundwater impacts.

7.4 Moolayember Formation

7.4.1 Distribution

The Moolayember Formation is the uppermost unit within the package of Triassic sediments. The Moolayember Formation subcrops to the west of the project site along the western edge of Darkies Range with a blanket of Tertiary sediments obscuring any outcrop. The formation comprises mudstones, siltstones and lithic sandstones reaching up to 600 m in thickness. As it occurs well to the west of the project site no monitoring bores targeted this formation.

Figure 23 shows structure contours for the base of the Triassic Moolayember Formation and the depth from the ground surface to the base.

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[3] http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW&doiw_refcodelist=QLD082

7.4.2 Hydrogeological parameters

The Moolayember Formation is widely considered a low permeability unit that confines the underlying Clematis Sandstone due to the marginal marine or tidal-flat depositional environment. However, there are instances of bores being screened in coarser water bearing zones of the unit, that presumably were deposited during periods of marine transgression, when higher energy sediments were deposited.

7.4.3 Recharge, flow and discharge

Diffuse rainfall recharge to the Moolayember Formation is considered to occur through the blanket of overlying Tertiary sediments, and also along leaky drainage lines and at the break of slope along the western edge of Darkies Range. Groundwater flows are expected to be controlled by surface topography and catchments with limited discharge into overlying formations. In the vicinity of the project site, groundwater movement is expected to follow local topography towards Lake Buchanan in the west and the Carmichael River in the south. Lake Buchanan is an inferred discharge zone for this unit and the underlying Clematis Sandstone.

7.4.4 Water quality

Whilst data is limited, private bore RN153581 recorded 'salty' water when drilled in 2013 (Figure 11). It is expected that water quality within this unit will be more variable than the Clematis Sandstone due to the lower permeability and longer groundwater residence times (i.e. slightly brackish to brackish).

7.4.5 Yields and use

There are eight private bores that intersect the Moolayember Formation within 20 km of the project site (Figure 11). Three of the bores are located on the Yarrowmere property, three on the Moonoomoo property, one on the Ulcanbah property and one on the Carmichael property. Bores typically intersect the Moolayember Formation at depths of between 60 m and 100 m depth. Lithological logs for the bores on the GWDB indicate the presence of sandy clay lenses within Moolayember Formation that yield between 0.15 L/s and 1.3 L/s of slightly brackish to saline water.

7.5 Tertiary Sediments

7.5.1 Distribution

The Tertiary Sediments blanket the low lying land either side of Darkies Range. The Tertiary Sediments are thin at the edge of the range and thicken as the topography falls to the east. The Tertiary Sediments comprise claystone and weakly indurated sandstone, and can look similar to weathered Clematis Sandstone in some instances. Figure 24 shows structure contours for the base of the Tertiary Sediments and the depth from the ground surface to the base.

7.5.2 Hydrogeological parameters

The Tertiary Sediments are dry and unsaturated along Darkies Range and the majority of the project site. A water table forms where the land surface falls and the sediments thicken in the eastern area of the project site. Figure 13 shows the extent of saturated Tertiary Sediments. Where drilling intersected saturated Tertiary sediments, testing has reported a low to moderate hydraulic conductivity of between 2.5 x 10^{-3} m/day and 6 x 10^{-1} m/day.

7.5.3 Recharge, flow and discharge

Recharge to the Tertiary Sediments is expected to be via diffuse rainfall and be enhanced along drainage lines with permeable beds or rock outcropping in the flowpath. The water table within the Tertiary Sediments is well below the level of the creek beds in the project site and remains below for at least 25 km to 40 km downstream. There is therefore no discharge from the Tertiary Sediments in the project site or within 25 km to 40 km downstream.

7.5.4 Water quality

The water samples collected from bores screened within saturated Tertiary sediments yielded fresh to slightly brackish water samples.

7.5.5 Yields and use

There are 17 private bores that intersect the Tertiary sediments within 20 km of the Project site (Figure 11). This makes it the most commonly accessed aquifer within the region, which is expected to be due to the lower cost of drilling into this formation. The bores are located on the Hyde Park, Dooyne and Moray Downs properties east of Darkies Range. The bores are typically drilled to 20 m to 30 m depth and are used for stock watering.

7.6 Quaternary Sediments

7.6.1 Distribution

The distribution of Quaternary sediments is described in Section 4.2.5. As discussed, investigations have confirmed that the minor drainage features and overland flowpaths present within the project site and downstream catchment are characterised by rock channels or exposed Tertiary materials. Extensive, deep alluvial deposits and associated shallow groundwater are therefore absent from the project site and surrounding area. Fluvial sediments present in the vicinity of the project site are limited to thin (less than 1 m) patches of mud and gravel that dry quickly following flow events.

Anecdotal information gathered during the bore census confirmed the history of landholder difficulties in sourcing cattle watering points in the vicinity from shallow groundwater. There are no confirmed alluvial bores in the vicinity of the project site.

This contrasts with the extensive alluvial deposits associated with the regionally significant Belyando and Carmichael River systems. These alluvial deposits are recharged by direct rainfall to large catchments and seepage from major rivers during periods of surface flow. These alluvial deposits are known to support a perennial water table and exhibit high yields and permeability. The Belyando River alluvium is located 50 km downstream of the project site and the Carmichael River alluvium is located in a separate catchment from the project site.

7.6.2 Hydrogeological parameters and recharge

As discussed, Quaternary sediments are largely absent from the project site. Consequently, hydraulic conductivity data for the project site is not available. These materials are present in the wider region. Data from the adjacent Carmichael River catchment shows that hydraulic conductivity is between 2.5 x 10^{-2} m/day and 1.1 m/day indicting a moderate to high permeability.

Localised recharge would be expected during flow events in drainage lines containing these sediments.

7.6.3 Yield and use

There are possibly two private bores that intersect the Quaternary sediments within 20 km of the project site. The bores are located east of Darkies Range on the Hyde Park property, along Bully Creek (RN103878) and near a minor tributary of Tomahawk Creek (RN89073) (Figure 11). Lithological logs for the two bores indicate they intersect water bearing gravels and coarse sandy clays, with yields of less than 2 L/S.

7.7 Summary of existing conceptual groundwater regime

This section describes the processes that control or influence the movement and storage of groundwater in a hydrogeological system. Figure 25 presents an east-west cross section through the project site, identifying the movement of groundwater within the region.

The geology of the region comprises geological units that dip in a westerly direction. However, the direction of groundwater flow is not down-dip, but from areas of high pressure to low pressure. Darkies Range forms an area of high pressure where groundwater is recharged through the outcropping Clematis Sandstone sediments, and at the break of slope where runoff concentrates after rainfall events. Whilst there is a recharge zone at Darkies Range, the depth to the water table is deep, and recharge is only expected to be a very small proportion of annual rainfall. The high evaporation rate in the region means sustained rainfall is required to saturate the soil profile and promote flow of water through the unsaturated profile, resulting in a low rate of recharge, compared to less arid areas.

Groundwater flows from the recharge area towards the west and the east. As the recharge rates are low, the discharge rates are also similarly low. Lake Buchanan, a large shallow in-land lake located within an internally draining basin, forms a discharge zone west of Darkies Range. The lake acts as a groundwater ‘sink’, with groundwater discharging to the lake bed and evaporating at the lake surface forming a salt crust. The fact Lake Buchanan is most commonly dry indicates evaporation rates from the lake exceed the inflow from underlying groundwater systems, confirming the low recharge/discharge volumes. Groundwater from Darkies Range also flows towards the east with the potentiometric surface reflecting the surface topography. The potentiometric surface remains at least 15 m below the ground surface over 20 km east of the project site and the only discharge mechanism from the groundwater systems is via pumping from private bores.

The fault that is located in the northern area of the project site also controls local groundwater flows. The fault trends in an approximately north-south direction with up to 100 m displacement within the Triassic and Permian sediments. The fault displacement truncates stratigraphic units and retards flow. This is particularly evident within the permeable Clematis Sandstone sediments on the eastern side of the fault. These permeable sediments have been displaced so that they now abut the low permeability Rewan Formation aquitard. Groundwater effectively pools against the low permeability unit and the fault forms a localised flow boundary.

The Tertiary Sediments thin out as topography increases towards Darkies Range and are largely unsaturated in the project site. There is no interaction between groundwater and surface water in the project site or surrounding area as the water table is between 25 m and 55 m below the base of the creeks and drainage lines.

8. Impact assessment

8.1 Introduction

Project activities have the potential to impact on the groundwater regime of the region through:

- Dewatering by extracting coal by longwall mining and open cut mining and in so doing lowering surrounding groundwater levels;
- Subsurface cracking of strata overlying the proposed longwall mine, changing the permeability of the overlying units and influencing groundwater levels;
- Construction of a TSF and power station waste storage facility (PSWSF), which have the potential to generate leachate and give rise to groundwater contamination;
- Use of hydrocarbons and chemicals which have the potential to give rise to groundwater contamination; and
- Formation of a residual void in the final mine landform, that has the potential to influence surrounding groundwater levels and quality.

This section provides a detailed assessment of these potential impacts and is structured as follows:

- Section 8.2 provides an overview of the proposed open cut and underground mining activities, and includes a general explanation of the way in which groundwater may be impacted by subsurface cracking associated with underground longwall mining;
- Section 8.3 provides an overview of the groundwater model that has been developed to assess the impact of mining. Appendix B provides a detailed technical description of the model development, construction and calibration;
- Sections 8.4 summarises the predictions of the groundwater modelling, including changes in groundwater levels during mining operations, groundwater inflow to the open cut pits and underground mine workings and post mine closure recovery of groundwater levels;
- Section 8.5 describes potential impacts to groundwater users and the environment;
- Section 8.6 outlines potential cumulative impacts with the adjacent Carmichael Coal Mine Project; and
- Section 8.7 describes potential for groundwater contamination from the TSF, PSWSF, overburden emplacements, and fuel and chemical storages.

8.2 Overview of mining

8.2.1 Open cut mining

The coal seams dip to the west and mining will generally progress down-dip in a westerly direction. The open cut pits will extend over a 12 km strike length and to a depth of approximately 300 m at the deepest point along the final highwall. Open cut mining will target the A and B Seams over the full extent of the mining area and the C seam in the southern section of open cut pit. Overburden removal will involve the use of multiple draglines and truck and shovel pre-stripping. In order to achieve the most efficient extraction of coal, several mining areas may be active at any point in time. Initial overburden will be stored in out-of-pit overburden emplacement areas to the east of the open cut mining area. As the open cut pits develop and progress, overburden will be placed in-pit.

The overburden emplacement areas will be rehabilitated progressively as the mine develops. Coal from the open cut pits will be mined with excavators, surface miners and rope shovels. Coal will be transported from the pits by haul trucks.

8.2.2 Underground mining

The project will involve establishing up to three longwall operations in the Northern and Southern Underground Mining Areas (Figure 2). The Southern Underground will involve a single longwall mining in the C Seam. The Northern Underground will involve dual longwalls mining in the A and D Seams.

The layout of the Northern Underground is constrained by the project site boundary as well as the geological fault that has been identified through the northern part of the Northern Underground area. The mine schedule indicates that the underlying D Seam will be extracted in advance of the overlying A Seam.

Seventeen longwalls panels are also planned in the Southern Underground. The panels are planned to be extracted before the overlying seams are mined by the open cut operation.

The longwall panels in the A, C and D Seams are designed at 300 m wide with two heading gateroads. Chain pillar widths are 35 m.

Longwall mining will result in subsidence of the overlying strata. Subsidence results in the progressive formation of shallow trough-like depressions on the surface relative to natural topography. Subsidence will fracture strata overlying the longwall panel and has the potential to depressurise or fully drain these effected strata.

Appendix B describes how the groundwater model represented the proposed mining sequence.

8.2.2.1 Overview of subsidence effects on hydrogeology

Subsidence predictions are provided in the EIS Subsidence Report. The EIS Subsidence Report explains that longwall mining results in collapse of the overlying rock strata into the void left by coal extraction. The collapsed or disturbed overburden material is referred to as the goaf. The collapse propagates upwards from the extracted seam until bulking of the goaf limits vertical movement and the tensile strength of the rock strata is sufficient to hold up the overburden without failure. There are a number of zones above the goafed area that have different degrees of cracking and the height of cracking is important in assessing the impact of mining on the groundwater regime and groundwater inflow to the mine.

The EIS Subsidence Report describes the following subsidence zones in terms of the known geology of the project site (in order of increasing height above the extracted coal seam):

- Fractured (or continuous cracking) zone – changes in vertical and horizontal permeability are possible;
- Dilated (or discontinuous cracking) zone – no changes in vertical permeability, possible changes in horizontal permeability and storativity; and
- Constrained zone – unaffected by subsurface subsidence cracking.

Figure 26 shows the conceptual model of subsurface subsidence cracking.

8.2.2.2 Zone of continuous cracking

In the continuous cracking zone immediately above the extracted seam, broken rock and rubble is highly fractured and permeable. Above this broken rock and rubble, de-stressing of overlying strata results in fractures extending through individual beds, opening of bedding planes and shearing and dislocation of beds ("continuous cracking"). This cracking exhibits increased vertical and horizontal transmissivity and storativity which decreases with increasing elevation above the extracted coal seam.

Water can potentially drain from an aquifer or surface water body if:

- the zone of continuous subsurface cracking intersects the water body; or
- there is a connection between the continuous subsurface cracking zone and any surface subsidence cracking.

The extent of continuous cracking above the proposed underground mining areas is predicted in the EIS Subsidence Report. This report concludes that there is likely to be:

- an upper bound height of 120 m for continuous cracking associated with single seam extraction; and
- a conservative continuous cracking height of 180 m above the upper seam extracted in dual seam mining areas.

The majority of the Northern Underground involves dual seam mining (A and D Seams). This area is overlain by the Clematis Sandstone. The interburden thickness between the A Seam and the base of the Clematis Sandstone is variable with a minimum thickness of 115 m to 120 m on the western side of the fault, and 140 m to 160 m on the downthrown eastern side.

The EIS Subsidence Report predicts that the height of connective cracking will be up to 120 m above the seam in single seam mining areas and 180 m above the A seam in the dual seam mining areas of the Northern Underground. The height of connective cracking would therefore intersect the overlying Clematis Sandstone. Section 8.3 and Appendix B describe how the continuous cracking was represented by the groundwater model.

8.2.2.3 Zone of discontinuous cracking

Above the continuous cracking zone, a zone of “discontinuous cracking” may form. In this zone the strata sag allowing bed separation. This discontinuous cracking increases horizontal permeability, but does not lead to continuous or connected vertical cracking.

8.2.2.4 Constrained zone

A constrained zone occurs above the discontinuous cracking zone and is characterised by a stress level at which rock masses are not disrupted sufficiently to increase their permeability. Hence there is no significant change in transmissivity or storativity, and therefore groundwater systems which occur in this zone are hydraulically unaffected by subsidence.

8.2.2.5 Zone of depressurisation

The process of open cut and underground mining reduces water pressures in surrounding rock units beyond the zone directly mined or cracked by subsidence. The extent and magnitude of the pressure reduction beyond this area depends on the properties of the coal seams and other hydrogeological units, and the fracture network generated by subsidence above the longwall mining area. This zone is referred to as the zone of depressurisation, and is greatest at the working face, gradually reducing with distance from the mining areas.

8.3 Overview of groundwater modelling

A 3D numerical groundwater flow model was developed for the project using MODFLOW-SURFACT. A detailed description of the modelling logic is provided in Appendix B.

The model represented the key geological units as 18 layers and extended 75 km north-south and 85 km east-west.

Development of the model was based on the high resolution geological model developed by the proponent. The geological model was further enhanced by inclusion of all published lithological logs within the model extents, including drilling logs from the adjoining Carmichael Coal Mine Project and the DNRM GWDB.

The numerical groundwater model reflects the groundwater regime described in Section 7. The model was calibrated to existing groundwater levels using reliable measurements from all representative bores located over an area of 6,375 km^2. A detailed description of the calibration method is provided in Appendix B. The objective of the calibration was to replicate the groundwater levels measured in the monitoring network installed at the project site and the adjacent Carmichael Coal Mine Project site, in accordance with modelling guidelines developed by Barnett et al (2012). The calibration achieved a 5.7% to 7.7% Scaled RMS error which is well within acceptable limits (i.e. 10%) as recommended by the modelling guidelines. The model calibration is therefore considered robust.

Once calibrated, the model was used to predict changes in groundwater levels and inflows to the proposed mining areas in response to the project, including simulated mining of the open cut pit and longwall panels in accordance with the proposed mine plan. The modelling approach included simulation of subsidence induced cracking above the longwall panels.

As discussed in the previous section, continuous subsurface subsidence cracking may extend through the Betts Creek Beds and Rewan Formation, into the Clematis Sandstone. Continuous cracking will increase the vertical hydraulic conductivity throughout the affected zone, with the magnitude of the increase likely to decrease with increasing height above the extracted seam. However, as with the prediction of cracking height, the prediction of permeability changes due to continuous cracking is inherently uncertain. Given the combined uncertainty in cracking height and permeability change, this assessment has conservatively adopted the following key modelling assumptions as the basis for the prediction of subsidence impacts on groundwater:

- the continuously cracked zone will be highly permeable; and
- where the zone of continuous cracking is predicted to intersect only part of a geological unit, the entire thickness of that geological unit is assumed to be continuously cracked.

Based upon these assumptions, the vertical conductivity assigned to the cracked Clematis Sandstone is so high as to be considered uniformly free-draining (Gale, 2007). These assumptions more than adequately account for any uncertainty associated with subsidence cracking prediction, and therefore provide a conservative basis for assessing potential worst case groundwater impacts. Modelling of subsidence cracking effects is discussed further in Section B2.2.

The sensitivity of the model predictions to the input parameters was tested and analysed. The analysis included varying model parameters and design features that could most influence the model predictions. The model parameters were adjusted to encompass the range of likely uncertainty in key parameters. Sensitivity analysis included testing the effects of changes in:

- horizontal hydraulic conductivity, vertical hydraulic conductivity, specific yield and specific storage of all geological units and overburden; and
- the rainfall recharge rate across the model domain and overburden.

In addition, specific sensitivity analyses were undertaken to test the influence of the geological fault on the predicted results. These sensitivity analyses comprised modelling the fault as:

- a low permeability fault plane running through the underground mining area, represented with the Horizontal Flow Barrier Package (HFB) set with a conductance term of 1x10^{-7} m^2/day; and
- a highly permeable fault plane represented by a zone of cells 75m x 75m cells set to the same hydraulic conductivity and specific storage as the Clematis Sandstone.

These changes capture extremes in the potential behaviour of the fault (i.e. groundwater conduit or groundwater flow barrier).

The analysis found that predicted groundwater inflows were most sensitive to changes in the storage parameters. Groundwater depressurisation is most sensitive to changes in storage and hydraulic conductivity during and post mining, while depressurisation was relatively insensitive to changes in the fault conditions.

It was also observed that changing the recharge and hydraulic conductivity parameters increased the overall model error. This shows that the magnitude of these changes reduced the ability of the model to match measured water levels, and indicates that the changes made during the sensitivity analysis are likely to represent conservative extremes for these parameters. Faulting sensitivity was concluded to result in no significant changes to calibration and predictions.

Overall, the sensitivity analysis confirmed that the measured sensitivity of the model calibration and predictions to changes in model parameters is in all instances acceptable.

Appendix B provides a detailed discussion of the sensitivity analyses undertaken. The following sections describe the predictions of the groundwater model.

8.4 Groundwater modelling predictions

8.4.1 Drawdown and depressurisation during mining operations

The influence of mining on the groundwater regime can be divided into two distinct areas. Firstly, the Northern Underground where dual seam underground mining is proposed, and subsidence fracturing will potentially interconnect the underground mining area with the overlying Clematis Sandstone, and secondly, the lower lying southern mining area where open cut mining and single seam underground mining is proposed, and the Clematis Sandstone is typically absent (except for a small proportion within the south of the project site where it is dry and unsaturated).

Figure 27 to Figure 33 show the predicted maximum depressurisation within the key stratigraphic units.

In the Northern Underground Mining Area, groundwater levels are predicted to be influenced by longwall mining in the A and D Seams. Longwall mining will depressurise the coal seam and overlying and underlying strata. Depressurisation will propagate through the Betts Creek Beds, Rewan Formation and Clematis Sandstone (where saturated), enhanced by the increased hydraulic conductivity of subsurface subsidence fracturing. The Clematis Sandstone is depressurised most significantly where it is saturated on the down thrown side of the fault and directly overlies the mining access roads (Figure 29). The saturated thickness of the Clematis Sandstone prior to mining in this area is some 50 m, with the modelling indicating lowering of the potentiometric surface by up to 33 m in response to subsidence and connective cracking. Beyond the mining area, the depressurisation of the Clematis Sandstone reduces with distance. Tertiary sediments do not occur on Darkies Range in the Northern Underground Mining Area where dual seam mining is proposed, and therefore will not be affected. The depressurisation in the coal seams and broader Betts Creek Beds in the north of the project site is localised to within approximately 2 km of the proposed underground mine workings (Figure 30 to Figure 33). In general the lateral extent of depressurisation is constrained in the Northern Underground Mining Area by the largely unsaturated and outcropping nature of the deposits that characterise the groundwater regime in this area (Figure 30 to Figure 33).

The depressurisation in the remainder of the project site differs from the Northern Underground Mining Area, because the Clematis Sandstone is either not present or, if present, is not saturated. The saturated extents of the Clematis Sandstone will not be intersected by either the open cut mine, or by fracturing above the Southern Underground. The Clematis Sandstone therefore is only impacted indirectly by mining reducing pressures in the Rewan Formation as it is exposed in the open cut mine, or fractured above the Southern Underground, resulting in pressure reduction propagating into the Clematis Sandstone. This results in the limited depressurisation shown in Figure 29. Groundwater levels may be lowered by up to 2 m in a zone around the Southern Underground Mining Area.

The zone of depressurisation in the target coal seams is comparable across the project site and is constrained to within a zone of about 2 km around the project site boundary.

The Southern Underground and Open Cut Mine will affect groundwater levels within the Tertiary sediments. Figure 27 shows the model predicts that depressurisation of the Tertiary sediments extends up to 2.2 km east and approximately 5.5 km north of the project site in the vicinity of the open cut pit.

In summary, the modelling indicates that during mining:

- Tertiary Sediments – groundwater levels impacted in a zone east and north of the Southern Underground and open cut area (Figure 27);
- Clematis Sandstone – water levels predicted to reduce by up to 33 m in a limited zone constrained along the fault that directly overlies the Northern Underground (Figure 29);
- Rewan Formation – drawdown remains within 3 to 4 km from mining areas (Figure 30); and
- Betts Creek Beds – drawdown remains within some 2 km of mining areas (Figure 30 to Figure 33).

Water levels in the Moolayember Formation are not predicted to be affected by the project.

8.4.2 Groundwater inflow to mining areas

Groundwater inflow to the mining operations will predominantly occur from the coal seams where these are exposed in the open cut and underground mining areas, and through the mine roof where longwall mining fractures and depressurises overlying strata. Figure 34 shows the predicted rate of seepage of groundwater into proposed mining areas.

The predicted seepage rates vary throughout the mining period. The variability is due to a range of factors including mining depth, permeability of strata, fractures generated above longwall mining areas, interactions between the mining areas and hydraulic gradients induced by the depressurisation. Seepage to the open cut mining area dominates the water budget in the early years of mining. This is due to the footprint of the open cut mine that extends along a 12 km strike length, to between about 200 m and 300 m below the ground surface. Inflow to the open cut pits peak at between 10 ML/day and 12 ML/day and then reduces to between 2 ML/day and 4 ML/day when underground mining of the C Seam occurs beneath the southern portion of the open cut mining area.

Seepage rates to the A and D Seams underground mines vary between 1 ML/day and 2 ML/day for the first 30 years of the project life. When mining of the D Seam is completed seepage rates into the overlying A Seam underground mine increase to between 2 ML/day and 4 ML/day due to the increased height of connective cracking and drainage of water from the overlying Clematis Sandstone where it is saturated above the mine. Groundwater inflow rates to the underground mining areas are less than the open cut areas, as longwall panels are allowed to flood after mining is completed.

The seepage rates presented in Figure 34 represent the total predicted removal of water from the groundwater systems. The actual volume of water pumped from the mining area will be less than that predicted by the model as a component of this water will be lost to evaporation, wetting of surfaces and infiltration, within mine workings.

8.4.3 Post closure groundwater recovery

The numerical model also simulated the rebound in the groundwater levels post mining. Appendix B outlines the set-up of the post mining groundwater model.

Predictive modelling was undertaken to simulate 200 years of groundwater recovery post mining. The simulation removed all drain cells representing mine dewatering from the coal seams, thus allowing the groundwater levels in the coal seams and the overlying water-bearing strata to recover.

The modelling indicates the final voids (and associated in-pit overburden emplacements) and the underground mines will gradually fill with water over time. This filling process will reduce the hydraulic gradient and magnitude of drawdown immediately surrounding the mined areas, but also allow the zone of depressurisation to continue to expand as water from the surrounding groundwater systems flow into the mines. Figure 35 to Figure 41 show the predicted extent and magnitude of drawdown at 200 years post mining. The post mining predictions are sensitive to recharge and hydraulic connectivity.

It is important to note that the model allows perfect hydraulic interconnection between the aquifers and aquitards represented in the model. The real world heterogeneity of the geology is not represented in the model. In reality, there are numerous structures in the groundwater systems, such as zones of poor interconnection between fracture networks, fine layering within sedimentary sequences and faults that would reduce the hydraulic interconnection between these units and further reduce the predicted post mining zone of influence. As the post mining zone of depressurisation expands, the potential to encounter more of these structures and boundaries to flow increases and the tendency of the model to over predict the impacts increases.

8.5 Project impacts

This section describes the operational and post-closure impacts of the project on:

- groundwater resources, including the GAB (Section 8.5.1);
- groundwater recharge (Section 8.5.2);
- groundwater users (Section 8.5.3);
- surface water features, including surface waterways, wetlands and Lake Buchanan (Section 8.5.4); and
- groundwater quality associated with contamination from mine waste storage facilities, hydrocarbon and chemical use, and the final void lake (Section 8.7).

The prediction and assessment of cumulative impacts of the project and other groundwater users is discussed in Section 8.6.

8.5.1 Impact on groundwater resources

The GAB underlies approximately one fifth of Australia extending beneath Queensland, New South Wales, South Australia and the Northern Territory. It stores an estimated 65,000 million ML of groundwater. The GAB WRP area comprises the area of the GAB that is regulated under Queensland legislation (as discussed in Section 2). The WRP plan area comprises at total of some 1.2 million km^2.

As discussed in Section 2.2.2, the Clematis Sandstone which occurs on the project site is an aquifer regulated under the GAB WRP. Both the Clematis Sandstone, and the Moolayember Formation which is located west of the project site, are within MU 3 of the Barcaldine North MA. The Ronlow Beds, which subcrop in excess of 26 km west of the project site, are within MU 2.

Modelling predictions for the Clematis Sandstone are described in detail in Section 8.4. Modelling predictions indicate that the project locally depressurises the Clematis Sandstone where it is saturated within and adjacent the project site (Figure 29). This causes groundwater levels to fall in the Clematis Sandstone by a maximum of 33 m where this unit overlies the Northern Underground area. In this area the existing saturated thickness is approximately 50 m.

This depressurisation will result in some water from the GAB MU 3 flowing into the mine. It will also reduce the volume of water flowing from the connected Rewan Formation and Betts Creek Beds into the Clematis Sandstone.

Figure 42 shows the conservatively estimated water take from the GAB aquifers due to the depressurisation induced by mining. It also shows the deeper non-GAB water take, which is equivalent to the mine inflow. The figure indicates the GAB water take gradually rises over the project life to approximately 4 ML/day as mining moves from areas where the Clematis Sandstone is dry to the saturated areas above the Northern Underground. The spike in water take of 9 ML/day occurs when fracturing from the A Seam longwall mine first interconnects the Northern Underground with the saturated Clematis Sandstone on the downthrown side of the fault. The water take from GAB aquifers is all from MU 3, which comprises the Clematis Sandstone and Moolayember Formation. There is no net take from the distant Ronlow Beds that are included in MU 2.

Post-mining, the conservatively estimated rate of water take from the GAB MU reduces due to the reduced hydraulic gradients present around the open cut and underground mining areas. The long term take from MU 3 peaks at almost 0.5 ML/day. There is also a very small take from the Ronlow Beds (MU 2) of 0.015 ML/day. This take occurs indirectly as a very slight reduction in flow from the Moolayember Formation to the Ronlow Beds. The volume is considered negligible. Based upon modelled groundwater inflows to the final void, the water take from non-GAB units (i.e. the Greater Western Sub-Artesian Area) is predicted to decrease post mining and reach an equilibrium of approximately 0.5 ML/day.

Obviously the predicted peak water take of up to 9 ML/day is inconsequential when compared to the estimated 65,000 million ML estimated to be stored within the GAB. On a local scale the acceptability of the predicted water take depends on the impact upon existing water users that hold entitlements, and the ability of the project to obtain a water entitlement. Section 8.5.2 outlines the impacts on water users with private bores.

Outside of the GAB aquifers there is a water take from the other formations in the Galilee Basin, i.e. the Betts Creek Beds and the Joe Joe Group. These formations are located within the Burdekin Water Resource Plan that does not regulate groundwater outside the coastal delta areas.

8.5.2 Impacts on groundwater recharge

It is considered improbable that there will be either a short term, or long term loss of recharge to the GAB as a result of the project. Section 7 explains that recharge occurs from diffuse rainfall, and is also likely concentrated at the break of slope and along drainage lines. Diffuse rainfall recharge will continue to occur during and post mining. A series of highwall drains will also allow water to flow around the open cut mine and mine infrastructure areas and continue to wet up drainage lines.

It is more likely that recharge will increase above the longwall mining areas and within the backfilled overburden emplacement areas post mining. This is likely in the underground mining areas due to the increased permeability of subsided strata, and the ability for these areas to store water. The overburden emplacement areas within the open cut mining area are relatively fractured compared to pre-mining conditions and it is also likely this will enhance recharge to the groundwater system.

For the purposes of ensuring that a conservative worst-case scenario is assessed, this additional recharge has not been considered when considering the post mining impacts.

8.5.3 Impact on groundwater users

Table 6 summaries the maximum predicted drawdown in private bores where the model predicts water levels will be reduced during mining. The location of the bores is shown on Figure 27 to Figure 33 along with the zone of influence.

Table 6 Predicted maximum drawdown in private bores

Registered No./Name	Assumed screen zone	Bore depth (m)	Water column (m)	Maximum drawdown - during mining (m)	Maximum drawdown - 200 years post mining (m)	Bore location
RN103875 (Roo Bore)	Betts Creek Beds	78.3	20.4	39.2	44.3	On 'Hyde Park' Within project site
RN103876 (Camp Bore)	Betts Creek Beds	74.1	24.6	16.1	25.1	On 'Dooyne' Within project site
RN90255	Clematis Sandstone	95.0	21.7	0.5	7.2	On 'Moray Downs' Outside project site
RN90259	Rewan Formation	104.9	64.4	0.4	5.3	On 'Moray Downs' Bore within Carmichael Coal Mine Project site
Lin Bore	Tertiary Sediments	-	-	0.1	4.8	On 'Dooyne' Outside project site
Lin Yards	Tertiary Sediments	-	-	0.1	4.5	On 'Dooyne' which Outside project site
Warratah Camp Bore	Clematis Sandstone	78.0	27.2	0.4	4.5	On 'Carmichael' Outside project site
Brumby Hole	Tertiary Sediments /Joe Joe Group	82.6	30.5	0.1	4.3	On 'Hyde Park' Outside project site
RN17981	Rewan Formation	61.0	19.8	0.2	3.7	On 'Moray Downs' Bore within Carmichael Coal Mine Project site
Pidgenhole	Tertiary Sediments	-	-	0.1	3.7	On 'Dooyne' Outside project site
Edgers Bore	Tertiary Sediments	-	-	0.02	3.5	On 'Dooyne' Outside project site
Wild Bore	Clematis Sandstone	-	-	0.1	3.1	On 'Carmichael' Outside project site
RN153583	Clematis Sandstone	97	20	0.54	2.5	On 'Moonoomoo' Outside project site
Gum Hole	Tertiary Sediments	43.9	3.1	0.02	2.5	On 'Hyde Park' Outside project site

Registered No./Name	Assumed screen zone	Bore depth (m)	Water column (m)	Maximum drawdown - during mining (m)	Maximum drawdown - 200 years post mining (m)	Bore location
RN132941	Tertiary Sediments	66.0	18.3	0.01	2.3	On 'Moray Downs' Bore within Carmichael Coal Mine Project site
Allens Bore	Tertiary Sediments	-	-	0.00	2.0	On 'Dooyne' Outside project site
RN153582	Clematis Sandstone	121	61.5	0.03	1.8	On 'Moonoomoo' Outside project site
RN17451 (Moonoomoo Bore)	Moolayember Formation	65.8	31.8	0.04	1.7	On 'Moonoomoo' Outside project site
RN132938	Betts Creek Beds	147.0	108.0	0.01	1.5	On 'Moray Downs' Bore within Carmichael Coal Mine Project site
8 Mile Bore	Moolayember Formation	-	-	0.1	1.4	On 'Yarrowmere' Outside project site
RN89072	Tertiary Sediments	42.7	20.4	0.00	1.3	On 'Hyde Park' Outside project site

A total of 52 private bores were identified during the bore census. The bore census indicated that groundwater use is sporadic and dispersed over a wide area due to the generally significant depth to groundwater and typically low yields. Water quality is variable, but is generally suitable for stock watering.

During mining operations the project is not predicted to impact bores located beyond the project site. Private bores within the project site will be managed through land access arrangements with landowners.

As discussed in Section 8.4.3, post mining groundwater effects have been predicted using highly conservative modelling assumptions (e.g. perfect hydraulic connectivity between geological units) over a 200 year period. Based upon these conservative modelling predictions, after a period of 200 years post-mining groundwater drawdown may affect up to 19 bores located beyond the project site during the long-term. Groundwater monitoring will be conducted over the 50 year life of the mine to confirm the actual extent of groundwater impacts and validate the conservative predictions. The results of the groundwater monitoring conducted over the life of the mine will be used to inform the reassessment of potential post-mining groundwater impacts and identification of any bores that will potentially be impacted in the long-term post mining. As part of mine closure planning, the proponent will enter into agreements with landholders of any potentially impacted bores. The groundwater monitoring program is described in Section 9.

Modelling predictions indicate that three bores are also predicted to have been impacted by the Carmichael Coal Mine Project. Cumulative impacts on groundwater users are discussed in Section 8.6.

8.5.4 Mining impacts on surface waters

8.5.4.1 Mining impacts on springs

The closest springs to the project site are the Doongmabulla Spring Complex, 22 km to the south of the proposed mining area. The Doongmabulla Spring Complex is registered under the GAB ROP as the closest spring that could support significant cultural and environmental values.

The Clematis Sandstone is the source aquifer for the springs. During mining the drawdown in this unit is not predicted to extend significantly beyond the project site (Figure 43). This is because the project does not directly impact on the Clematis Sandstone in the south of the project site. Impacts on the Clematis Sandstone are limited to the upward propagation of depressurisation through the low permeability underlying Betts Creek Beds and Rewan Formation. In addition, the Clematis Sandstone is largely dry and unsaturated at its margins, including in the south-west of the project site adjacent the proposed mining areas (Figure 22).

The maximum predicted extent of depressurisation extends to 4 km from the project site during mining and 11 km post mining. This means that depressurisation impacts associated with the project remains at least 11 km from the Doongmabulla Spring Complex during or post mining and therefore no impacts on the springs are predicted.

Figure 43 shows the extent of drawdown, both during and post mining in the Clematis Sandstone in relation to the springs.

8.5.4.2 Mining impacts on Lake Buchanan

Lake Buchanan is located 17 km to the west of the proposed mining area and is considered to be an area of groundwater discharge and evaporation. The maximum predicted zone of depressurisation during project operations and post closure does not extend to the lake, remaining between 6 km and 17 km away post mining. The project will therefore not impact the groundwater levels in the Lake Buchanan area.

8.5.4.3 Mining impacts on surface drainage

No watercourses as defined under the Water Act are located on the project site.

As discussed in Section 7, groundwater levels in the vicinity of the project site are at significant depth, typically between 25 and 100 m below the ground surface. This is because the project site is located in the headwaters of the catchment where the topography is elevated and recharge relatively low. The surface drainages have only short duration highly ephemeral flows following rainfall. Within the predicted extents of drawdown, the groundwater table is at least 15 m below the base of any drainage feature, and typically greater than 20 m. Groundwater therefore does not provide baseflow to surface drainages, but instead moves underground to the west and east away from the project site. Therefore, the depressurisation predicted to occur in the groundwater system will not impact on surface drainages as there is no direct interconnection between these systems.

8.6 Cumulative mining and coal seam gas impacts

The following activities also extract groundwater and therefore require consideration of the potential for cumulative impacts with the project:

- agricultural stock bores;
- coal seam gas projects; and
- coal mining projects.

No coal seam gas projects are currently proposed in the vicinity of the project site.

Private bores are relatively sparsely spread in the region, and records indicate yields from the bores are relatively low at typically less than six litres per second. The total extraction volumes of groundwater are low and this pumping has negligible effect upon the regional groundwater levels. Therefore, the pumping from private bores will not contribute significantly to cumulative groundwater impacts.

There are currently five coal mines in the early stages of development in the Galilee Basin; Carmichael Coal Mine Project, Kevins Corner Mine, Alpha Mine, China First Mine and South Galilee Coal Project. Only the Carmichael Coal Mine Project is located within relatively close proximity to the project with the remainder between 125 km and 200 km to the south of the project site. Only the Carmichael Coal Mine Project has the potential to generate a cumulative impact on groundwater levels.

As discussed in Section 3.2, the project site adjoins the Carmichael Coal Mine Project site, a large scale underground and open cut coal mine. The Carmichael Coal Mine Project is approved but has not yet commenced construction. Given the close proximity of this project site there is the potential for the two projects to generate a cumulative impact on groundwater levels.

The method of superimposition has been adopted for assessing cumulative groundwater impacts associated with the Carmichael Coal Mine Project. This involves presenting drawdown contours reported for each project from the same unit on a single map and determining where they overlap. The cumulative impact occurs within the overlapping zone (Figure 44 to Figure 49). By comparing the mining and post mining scenarios for each mine, this approach provides a conservative assessment of the cumulative worst-case in terms of changes to groundwater levels. Predictions relating to the Carmichael Coal Mine Project were sourced from the Carmichael Coal Mine Project EIS and Supplementary EIS documents. The 1 m drawdown contour has been taken as the limit of impact for each project.

This cumulative assessment shows (by stratigraphic unit):

- Quaternary Sediments are typically absent at the project site and may be present as thin, dry sediments in the downstream drainage features. More extensive Quaternary Sediments are present in the adjacent Carmichael River catchment which contains a significant watercourse. The sediments of the Carmichael River may be saturated, however impacts from the project site do not extend this far and therefore there is no cumulative impact during mining, or post mining (Figure 27);
- Tertiary Sediments – no cumulative impact during mining, but a cumulative impact post mining;
- Clematis Sandstone – no cumulative depressurisation during or post mining; and
- Betts Creek Beds:
    - A/B Seam – cumulative impact during and post mining; and
    - D Seam – cumulative impact during and post mining.

Figure 44 to Figure 49 demonstrates these results for the four stratigraphic units. The figures show the cumulative impact increases post mining and occurs in the area where the project and Carmichael Coal Mine Project are in close proximity, i.e in the northern part of Carmichael Coal Mine Project site and southern portion of Project China Stone site.

During mining the zone of cumulative drawdown within the Tertiary Sediments do not overlap. Post mining, the project increases the drawdown predicted for Carmichael Coal Mine Project by up to 20 m. There are no private bores located within this zone (Figure 44 and Figure 45).

The Carmichael Coal Mine Project does not directly mine the Clematis Sandstone within the open cut mines, or fracture it in the underground mines. The Carmichael Coal Mine Project groundwater model therefore predicts no significant depressurisation of the Clematis Sandstone greater than 1 m during mining and post closure. The model for Project China Stone therefore predicts no cumulative impacts on the Clematis Sandstone. While the Doongmabulla Spring Complex is fed by the Clematis Sandstone aquifer, the springs are beyond any zone of cumulative influence and therefore there will be no cumulative impact on these springs.

The cumulative impact is most extensive in the coal seams targeted by the mining operations, and occurs with drawdown overlapping in the A Seam and D Seam by the end of mining. The project effects on groundwater level are most extensive within the Southern Underground, which is directly mined, where over 100 m of additional depressurisation could occur during mining. Post mining the cumulative impact reduces as the mined workings flood with water. Outside this area the project could add between 1 m to 50 m to the drawdown predicted for the Carmichael Coal Mine Project.

The project impacts on the C Seam are shown on Figure 32 and Figure 40 and discussed in Section 8.4. However, the Carmichael Coal Mine Project EIS or Supplementary EIS (GHD, 2013) do not provide any predictions of groundwater impacts in the C Seam.

It is anticipated that the Carmichael Coal Mine Project groundwater impacts on the C Seam would be comparable to the Carmichael Coal Mine Project impacts on the D Seams. On this basis, the cumulative C Seam impacts of the Carmichael Coal Mine Project (based on D Seam impacts) and Project China Stone (Figure 48 and Figure 49) are anticipated to be equivalent to those presented for the D Seam.

The zone of cumulative impact is concentrated largely in the area where the two projects adjoin. Groundwater use is very limited in this area, with only three private bores potentially experiencing a cumulative impact. These are:

- Allens bore on ‘Dooyne’;
- RN132938 on ‘Moray Downs’; and
- RN103875 on ‘Hyde Park’.

The Allens bore is predicted to be impacted by the Carmichael Coal Mine Project and is therefore likely to be subject to a make good agreement with Adani Mining Pty Ltd. RN103875 is within the project site and will be effectively dealt with by the land access agreement for the mining lease application. RN1329385 is owned by Adani Mining Pty Ltd and is within the Carmichael Coal Mine Project site and will be impacted by the Carmichael Coal Mine Project.

8.7 Impact on groundwater quality

The project will involve the construction of mine infrastructure, mainly within the eastern portion of the project site. Key infrastructure is outlined in Section 1.

Seepage associated with mine waste storage facilities and hydrocarbon and chemical storage is the main potential source of groundwater contamination. Rainfall runoff associated with mine infrastructure is addressed in the EIS Surface Water Section.

Potential groundwater quality impacts associated with these contamination sources are addressed in the following sections. The potential for impacts to groundwater quality have been determined using information on seepage water quality and the conceptual design of mine waste storage facilities derived from the EIS Geochemistry Report and the EIS Mine Waste Storage Facility Conceptual Design Report, respectively.

Overburden, coal (including rejects and tailings) and power station waste runoff quality is based upon geochemical testing and analysis presented in the EIS Geochemistry Report. However, it should be recognised that direct application of geochemical data can be misleading. Using sample pulps (ground to passing 75 µm) provides a very high surface area to solution ratio, which encourages mineral reaction and dissolution of the solid phase. As such, the results of geochemical tests on water extract solutions represent an assumed 'worst case' scenario for undiluted leachate from tested materials. The quality of actual runoff and/or seepage water from these materials would be better than these results due to the less optimum conditions for leaching and the significant dilution from fresh rainfall runoff. The results are therefore not representative of water quality and for the purpose of this assessment, geochemical test results are a highly conservative representation of water quality.

8.7.1 Overburden emplacement areas and final void lakes

Initial overburden will be stored in out-of-pit overburden emplacement areas to the east of the open cut mining area. Once the open cut pits have been developed, overburden will be placed in-pit. The overburden emplacement areas will be rehabilitated progressively as the mine develops using proven rehabilitation techniques.

Kinetic Leach Columns (KLC) testing of samples of interburden and overburden recorded a median EC value in the leachate of 346 µS/cm and a slightly alkaline pH. The open cut voids will form a permanent sink post mining, with water leaching through the spoils moving into the lake formed within the final void. The geochemical test work indicates that the risk of saline surface leachate from spoil material is low in the short term and is expected to diminish with time as soluble salts are leached from this material. The EIS Geochemistry Report also shows that the concentration of soluble metals and major ions in runoff and seepage from overburden is likely to remain within applied water quality guideline criteria and is unlikely to present any significant environmental risks for on-site or downstream water quality.

The EIS surface water assessment determined the water levels within the final void would recover to an equilibrium level of 255 mAHD. This level is well below the pre-mining groundwater levels and means the final void will act as a sink to groundwater flow. Water will evaporate from the lake surface, and draw in groundwater from the surrounding geological units. Evaporation from the lake surface will concentrate salts in the lake slowly over time. This gradually increasing salinity will not pose a risk to the surrounding groundwater systems as the final void will remain a permanent sink.

8.7.2 Tailings storage facility

As discussed in Section 1, tailings generated by the project will be stored in an out of pit TSF. The TSF is located to the east of the open cut mining areas (Figure 2). The underlying geology comprises Tertiary sediments overlying the Joe Joe Group, and is relatively distant from the GAB units. Two bores (MB 20 and MB 32) were drilled in this area to investigate the potential for a shallow water table and the nature of the underlying strata. Both holes were terminated in dry sandstone at 25 m below the surface. Subsequent measurements indicated the water table is deeper than 25 m below the ground surface in the area of the TSF. Groundwater samples collected from other bores screened within saturated Tertiary sediments recorded EC values between 500 µS/cm and 1,000 µS/cm.

Geochemical testing on tailings materials reporting to the TSF was undertaken for the EIS Geochemistry Report. The testing included measuring pH and EC in KLC. Static and kinetic leachate test results presented in the geochemical assessment concluded that coal rejects and tailings are likely to generate low to moderate salinity runoff with a median KLC EC of 279 µS/cm.

The geochemical testing indicates any leachate from the TSF is likely to be better quality than the Tertiary groundwater so degradation of groundwater quality is improbable should any seepage from the TSF occur. There is only one bore in proximity to the TSF (RN36400), and this bore will be removed during construction of the TSF, so therefore the risk to groundwater users is considered low.

Leachate results indicate that seepage generated by the storage of tailings at the TSF is likely to be pH neutral to alkaline, again similar to the in-situ groundwater in the Tertiary sediments. The concentration of soluble metals and major ions in TSF seepage is predicted to be low. The exception was selenium that was recorded in two KLC columns with composite coal rejects marginally above the stock watering guideline. Dissolved metals in the Tertiary groundwater samples do not exceed guidelines for stock water.

The work indicates the water table at the site of the proposed TSF is relatively deep, and that the leachate generated from the facility will of a similar quality to the Tertiary groundwater. The facility will be designed to minimise leachate generation, however were seepage to occur a degradation in groundwater quality is unlikely. There are no private bores within close proximity to the proposed TSF so the risks to the groundwater regime are low.

8.7.3 Power station waste storage facility

The proposed power station waste has been tested as part of the EIS Geochemistry Report. KLC testing indicates this material is likely to generate waters with neutral pH and a median EC of approximately 907 µS/cm. Concentrations of fluoride, molybdenum and selenium exceeded stock watering guidelines in initial leaches, but reduced to below guideline levels after 26 weeks.

The proposed PSWSF is adjacent the proposed TSF, where groundwater investigations shows the water table to be at depth. Leachate generated from the power station waste storage facility will of a similar quality to the groundwater within the underlying Tertiary sediments. The power station waste storage facility will be designed to minimise leachate generation, however were seepage to occur a degradation in groundwater quality is unlikely. There are no private bores within close proximity to the proposed TSF so the risks to groundwater users are unlikely.

8.7.4 Hydrocarbons

There is potential for groundwater contamination to occur as a result of hydrocarbon and metals contamination from workshops and fuel storage areas. However, adequate bunding and immediate clean-up of spills which is standard practice and a legislated requirement at mine sites should prevent the contamination of the groundwater regime.

9. Groundwater monitoring and management plan

9.1.1 Ongoing Pre-Mining Baseline Monitoring

The established groundwater monitoring network comprises 31 monitoring bores and 12 VWPs at 24 locations across the project site and surrounding area (Figure 12). Data from this monitoring network enabled confirmation of baseline groundwater levels and quality from representative hydrogeological units.

The groundwater monitoring network established as part of EIS groundwater investigations will be maintained throughout the life of the project. Any monitoring bores or VWPs that are removed by mining during the life of the project will be replaced, where necessary.

Recording of groundwater levels from existing monitoring bores and VWPs will continue until the commencement of project construction. This will provide a long-term dataset that will enable natural water level fluctuations (such as responses to rainfall) to be distinguished from potential water level impacts due to depressurisation resulting from mining activities.

Groundwater quality monitoring will also continue until the commencement of project construction. This will establish a robust, long-term baseline groundwater quality that can be used to determine site-specific groundwater contaminant trigger levels and detect any changes in groundwater quality arising from mining activities during and post mining.

This baseline groundwater and level data will be reviewed prior to project construction to establish which water quality parameters should continue to be monitored and the frequency of the groundwater monitoring. All determinations of groundwater quality and levels will be undertaken by an appropriately qualified person.

9.1.2 Operations Phase Groundwater Monitoring

An operations phase groundwater monitoring program is required to identify any significant departure from baseline conditions or the EIS model predictions that could result in significant impacts to water resources, water users and environmental values. The proposed monitoring program will monitor groundwater levels and quality in relation to:

- Groundwater take from the GAB;
- Groundwater take from the Greater Western Sub-Artesian Area;
- Drawdown impacts on private water supply bores;
- Indirect depressurisation impacts on the water table in the Tertiary sediments; and
- Water quality impacts arising from mine waste storage facilities.

An operations phase monitoring program has been developed to meet these monitoring objectives and confirm the project effects on groundwater throughout the project operations phase. Details of the proposed operations phase groundwater monitoring program are provided in the EIS Environmental Management Section.

The existing monitoring bores will operate as groundwater compliance points. Site-specific reference conditions for the groundwater regime will be derived from ongoing pre-mining baseline monitoring and EIS groundwater model predictions.

The basis of calculation of groundwater quality triggers and limits is documented in the EIS Environmental Management Section. All proposed groundwater quality triggers and limits will be determined prior to project construction using long-term baseline data collected from the ongoing monitoring program. Monitoring data will be reconciled with the proposed groundwater quality triggers and limits on a quarterly basis to identify any deviations from long-term baseline groundwater quality. In accordance with the model EA conditions, the proponent will investigate any exceedance of the proposed groundwater quality triggers.

Groundwater level trigger thresholds have also been developed for each of the proposed monitoring bores. Groundwater level trigger thresholds are set at 90% of the predicted maximum water level change at each bore to allow for early identification of any unexpected impacts on groundwater levels, as shown in the EIS Environmental Management Section. Groundwater level monitoring data will be reconciled with the proposed groundwater level trigger thresholds on a quarterly basis to identify any deviations from the modelled predictions. In accordance with the model EA conditions, the proponent will investigate any exceedance of the proposed groundwater level trigger thresholds to determine whether there is a significant departure from the modelled predictions.

The proponent will also comply with any additional monitoring and reporting requirements under the Water Act water licensing regime, as discussed in Section 2.2.

10. References

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11. Abbreviations

AGE	Australasian Groundwater and Environmental Consultants Pty Ltd
ALS	ALS Environmental Laboratories
ANZECC	Australian and New Zealand Environment and Conservation Council
BoM	Bureau of Meteorology
CHPP	Coal Handling and Preparation Plant
CRD	Cumulative Rainfall Departure
EC	electrical conductivity
DotE	Department of the Environment
DME	Department of Mines and Energy
DNRM	Department of Natural Resources and Mines
EIS	Environmental Impact Assessment
EPBC Act	Environment Protection and Biodiversity Conservation Act
EPP	Environmental Protection Policy
EPP Water	Environmental Protection Policy Water
GAB	Great Artesian Basin
GAB ROP	Great Artesian Basin Resource Operations Plan
GAB WRP	The Water Resource (Great Artesian Basin) Plan
GMA	Groundwater Management Area
GSQ	Geological Survey of Queensland
GWDB	DNRM Groundwater Database
L/s	litres per second
m	metres
MA	Management Areas
mAHD	metres above Australian height datum
m/day	metres per day
MBGS	McElroy Bryan Geological Services
ML	megalitres
ML/year	million litres per year
mm/yr	millimetres per year
MNES	Matters of National Environmental Significance
Mtpa	Million tonnes per annum
MU	Management Units
NATA	National Association of Testing Authorities
No.	number
PSWSF	Power station waste storage facility

RMS	root mean square
ROM	Run of Mine
ROP	Resource Operations Plan
TDS	total dissolved solids
the project	Project China Stone
TSF	Tailings Storage Facility
VWP	vibrating wire piezometer
Water Act	Queensland Water Act 2000
Water Reform Act	Water Reform and Other Legislation Amendment Act 2014
WRP	Water Resources Plan
µS/cm	microsiemens per centimetre
%	percentage

12. Glossary

Alluvium - Sediment (gravel, sand, silt, clay) transported by water (i.e. deposits in a stream channel or floodplain).

Aquiclude - A low-permeability unit that forms either the upper or lower boundary of a ground-water flow system.

Aquifer - Rock or sediment in a formation, group of formations, or part of a formation which is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.

Aquifer, confined - An aquifer that is overlain by a confining bed. The confining bed has a significantly lower hydraulic conductivity than the aquifer.

Aquifer, perched - A region in the unsaturated zone where the soil may be locally saturated because it overlies a low-permeability unit.

Aquifer, semi-confined - An aquifer confined by a low-permeability layer that permits water to slowly flow through it. During pumping of the aquifer, recharge to the aquifer can occur across the confining layer. Also known as a leaky artesian or leaky confined aquifer.

Aquifer, unconfined - An aquifer in which there are no confining beds between the zone of saturation and the surface. There will be a water table in an unconfined aquifer. Water-table aquifer is a synonym.

Aquitard - A low-permeability unit than can store ground water and also transmit it slowly from one aquifer to another.

Colluvium - Sediment (gravel, sand, silt, clay) transported by gravity (i.e. deposits at the base of a slope).

Cone of Depression - The depression in the water table around a well or excavation defining the area of influence of the well. Also known as cone of influence.

Drawdown - A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping of ground water from wells or excavations.

Hydraulic Conductivity - A measure of the rate at which water moves through a soil/rock mass. It is the volume of water that moves within a unit of time under a unit hydraulic gradient through a unit cross-sectional area that is perpendicular to the direction of flow.

Hydraulic gradient - The change in total head with a change in distance in a given direction. The direction is that which yields a maximum rate of decrease in head.

Infiltration - The flow of water downward from the land surface into and through the upper soil layers.

K - Hydraulic conductivity.

Model calibration - The process by which the independent variables of a digital computer model are varied in order to calibrate a dependent variable such as a head against a known value such as a water-table map.

Packer test - An aquifer test performed in an open borehole; the segment of the borehole to be tested is sealed off from the rest of the borehole by inflating seals, called packers, both above and below the segment.

Piezometer - A non-pumping well, generally of small diameter, that is used to measure the elevation of the water table or potentiometric surface. A piezometer generally has a short well screen through which water can enter.

Porosity - The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment.

Potentiometric surface - A surface that represents the level to which water will rise in tightly cased wells. If the head varies significantly with depth in the aquifer, then there may be more than one potentiometric surface. The water table is a particular potentiometric surface for an unconfined aquifer.

Pumping Test - A test made by pumping a well for a period of time and observing the response/change in hydraulic head in the aquifer.

Slug Test - A test made by the instantaneous addition, or removal, of a known volume of water to or from a well. The subsequent well recovery is measured.

Specific yield - The ratio of the volume of water a rock or soil will yield by gravity drainage to the volume of the rock or soil. Gravity drainage may take many months to occur.

Storativity - The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer, per unit change in head.

Transmissivity - A measure of the rate at which water moves through an aquifer of unit width under a unit hydraulic gradient.

Unsaturated zone - The zone between the land surface and the water table. It includes the root zone, intermediate zone, and capillary fringe. The pore spaces contain water at less than atmospheric pressure, as well as air and other gases. Saturated bodies, such as perched ground water, may exist in the unsaturated zone. Also called zone of aeration and vadose zone.

Water budget - An evaluation of all the sources of supply and the corresponding discharges with respect to an aquifer or a drainage basin.

Water table - The water table is the surface where the water pressure head is equal to the atmospheric pressure. It represents the top of the zone where subsurface strata are saturated with groundwater.

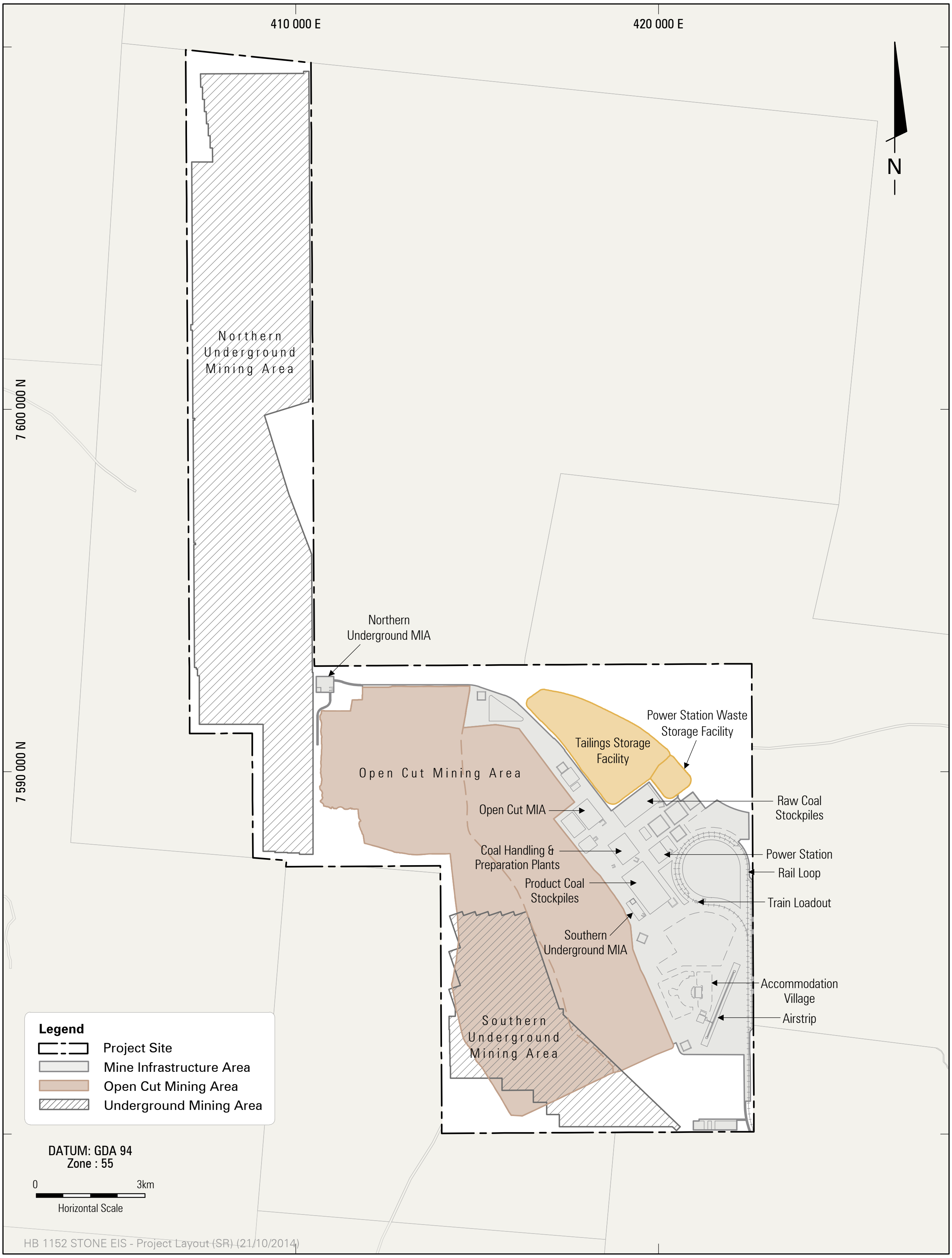
List of figures

PROJECT CHINA STONE

MACMINES AUSTASIA | Hansen Bailey ENVIRONMENTAL CONSULTANTS

Project Location

FIGURE 1



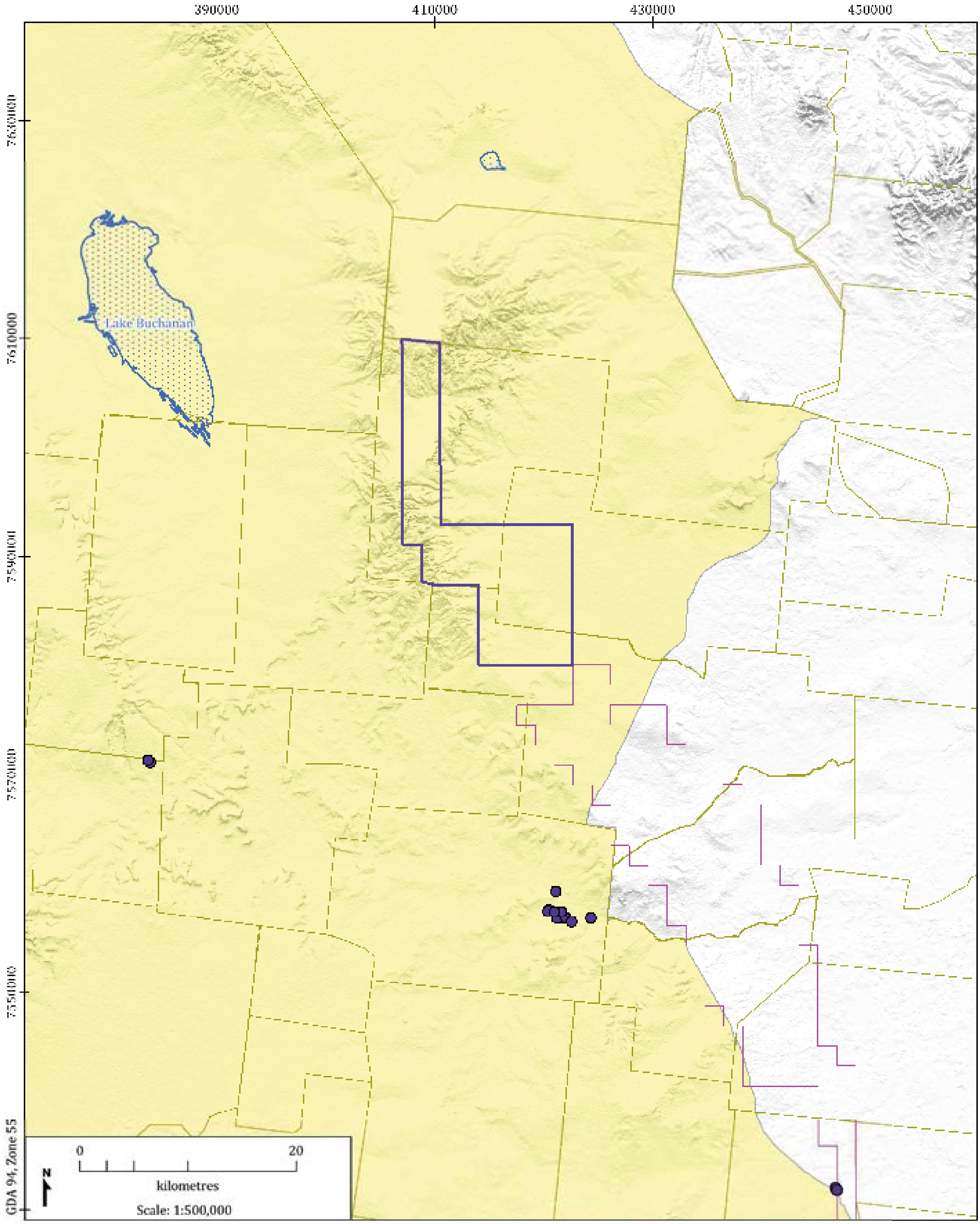
PROJECT CHINA STONE

MACMINES AUSTASIA

Hansen Bailey
ENVIRONMENTAL CONSULTANTS

Project Layout

FIGURE 2



LEGEND:

— Project site
— Carmichael Coal Mine Project
🟨 Barcaldine North Management Area
● GAB Springs (Fensham and Fairfax (2006) Springs of Queensland)
☐ Property boundaries
▨ Surface water feature

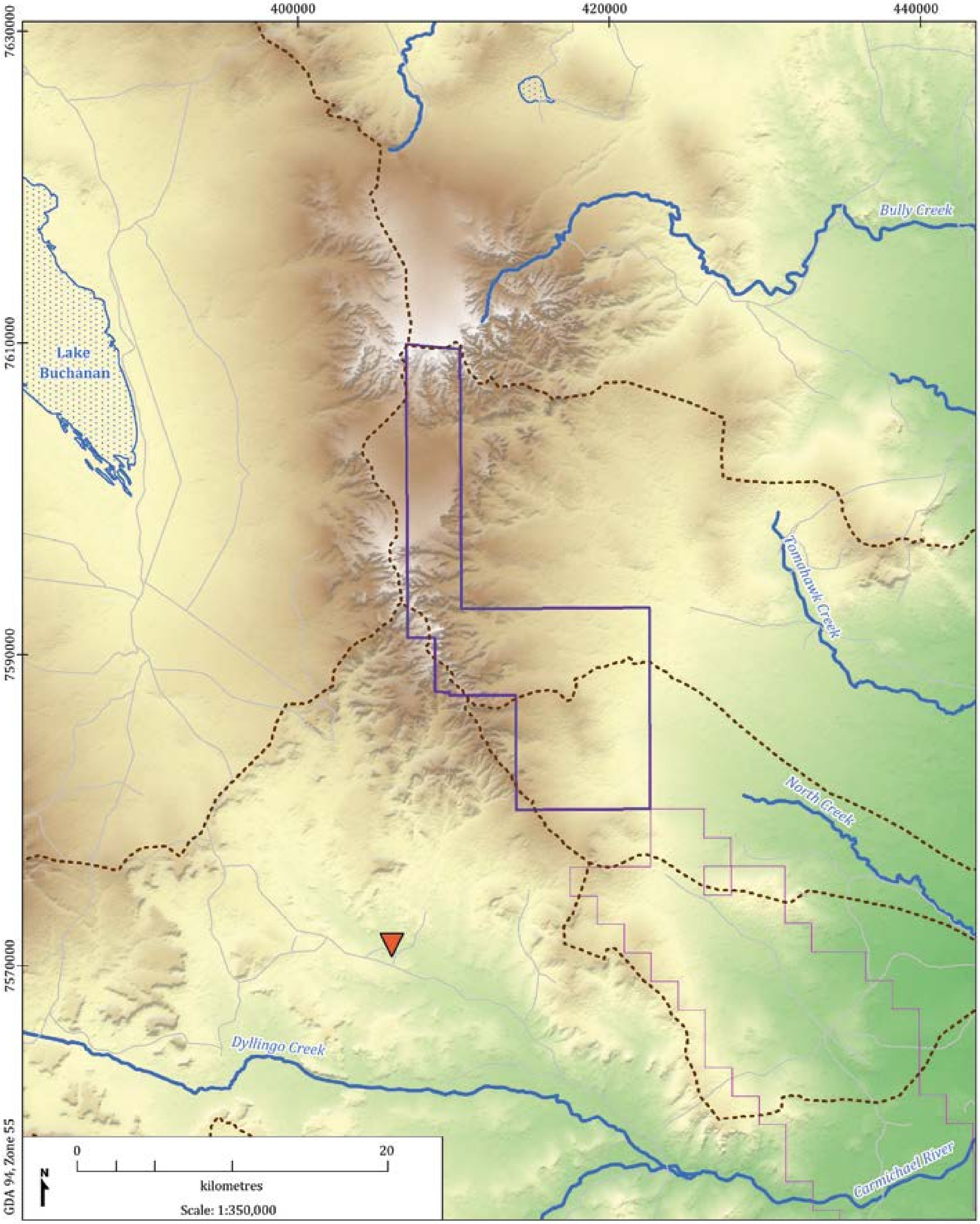
Project China Stone (G1587)

Water Resource (Great Artesian Basin) Plan 2006 Area

AGE

DATE: 24/6/2015

FIGURE No: 3



LEGEND:

- ▬ Project site
- ▬ Carmichael Coal Mine Project
- - - - Catchment boundary
- ▬ Major drainage
- ▬ Road
- ▼ Carmichael weather station (036122)
- ⬚ Surface water feature

Elevation (mAHD)

500
400
300
200

Project China Stone (G1587)

Topography and drainage

DATE: 24/6/2015

FIGURE No: 4

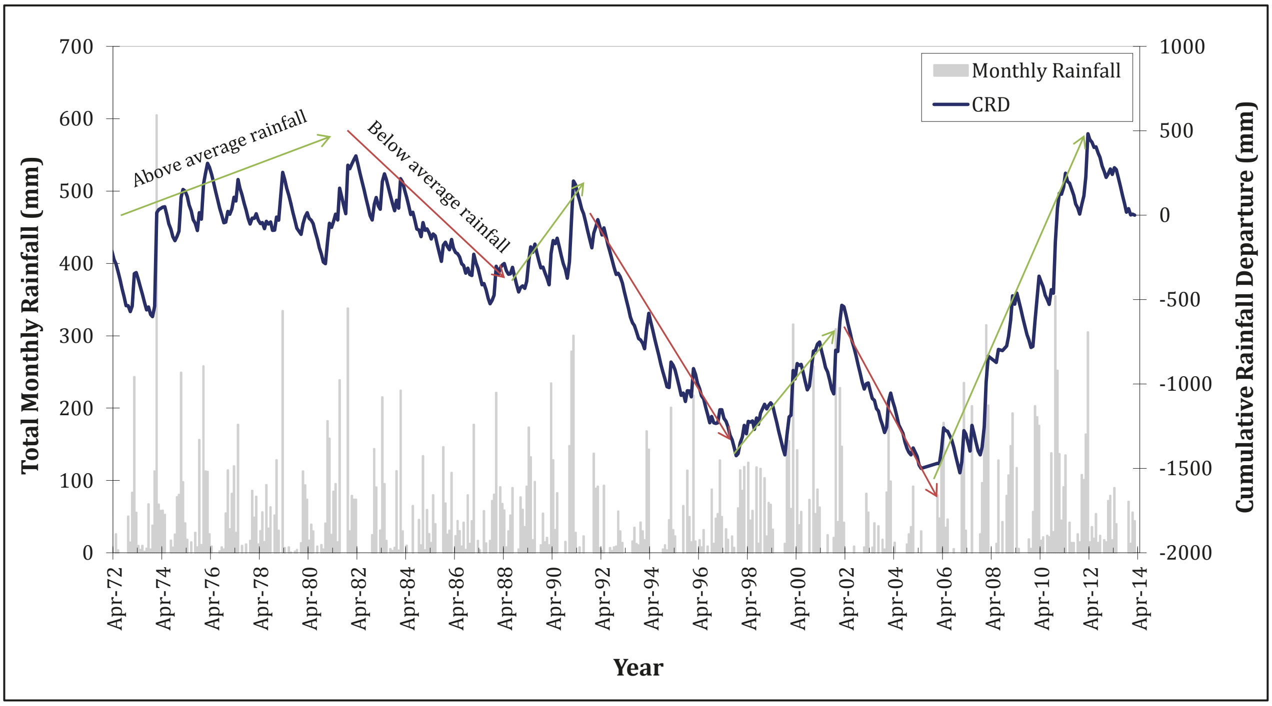
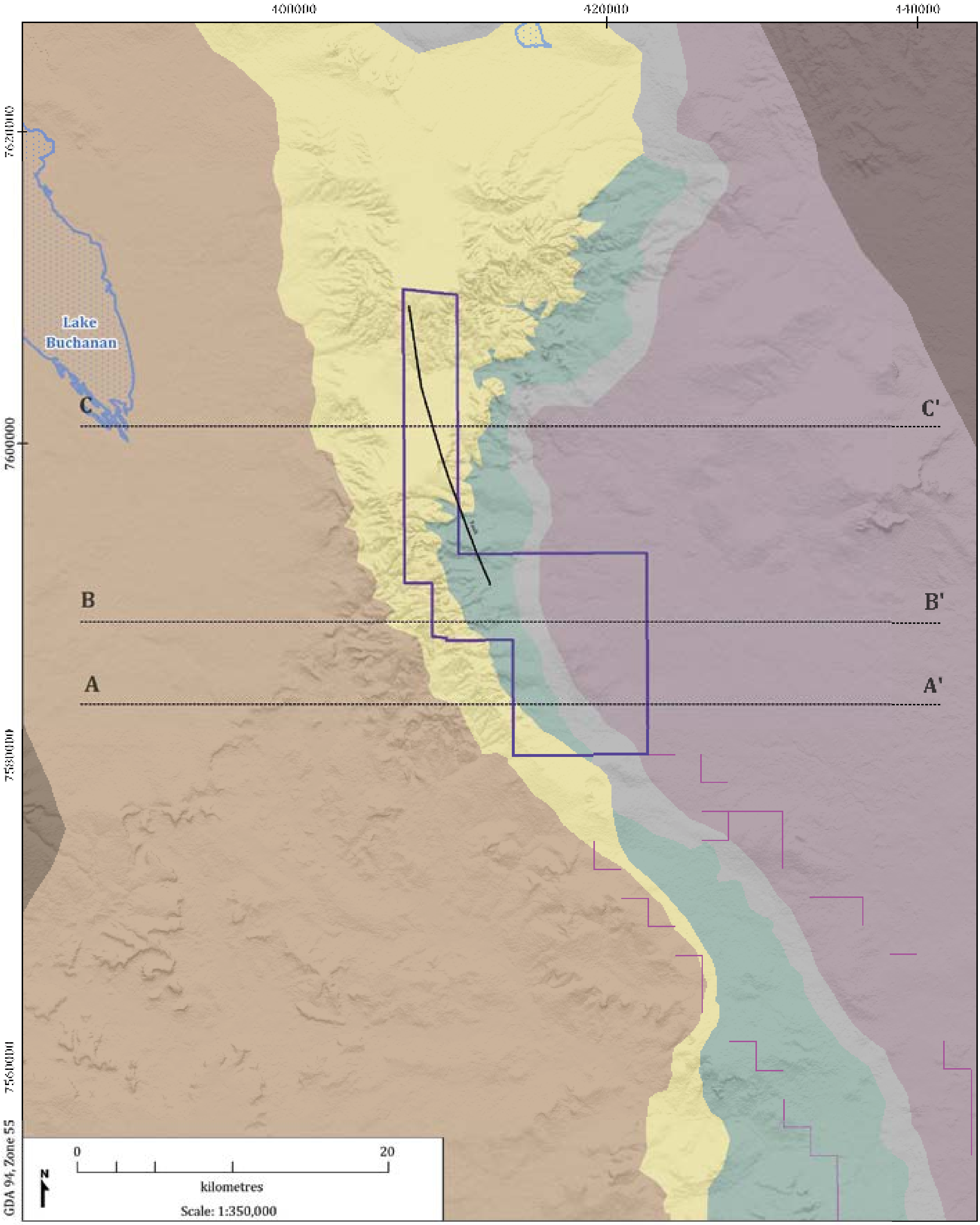


Figure 5 Cumulative rainfall departure



LEGEND:

- Project site
- Carmichael Coal Mine Project
- Fault
- ⋯⋯ Cross-section
- ▨ Surface water feature

- ■ Carboniferous - Drummond Basin
- ■ Permian - Joe Joe Group
- ■ Permian - Betts Creek Beds
- ■ Triassic - Rewan Formation
- ■ Triassic - Clematis Sandstone
- ■ Triassic - Moolayember Formation
- ■ Jurassic - Ronlow Beds

Project China Stone (G1587)

Geological units sub-cropping under Tertiary/Quaternary sediments

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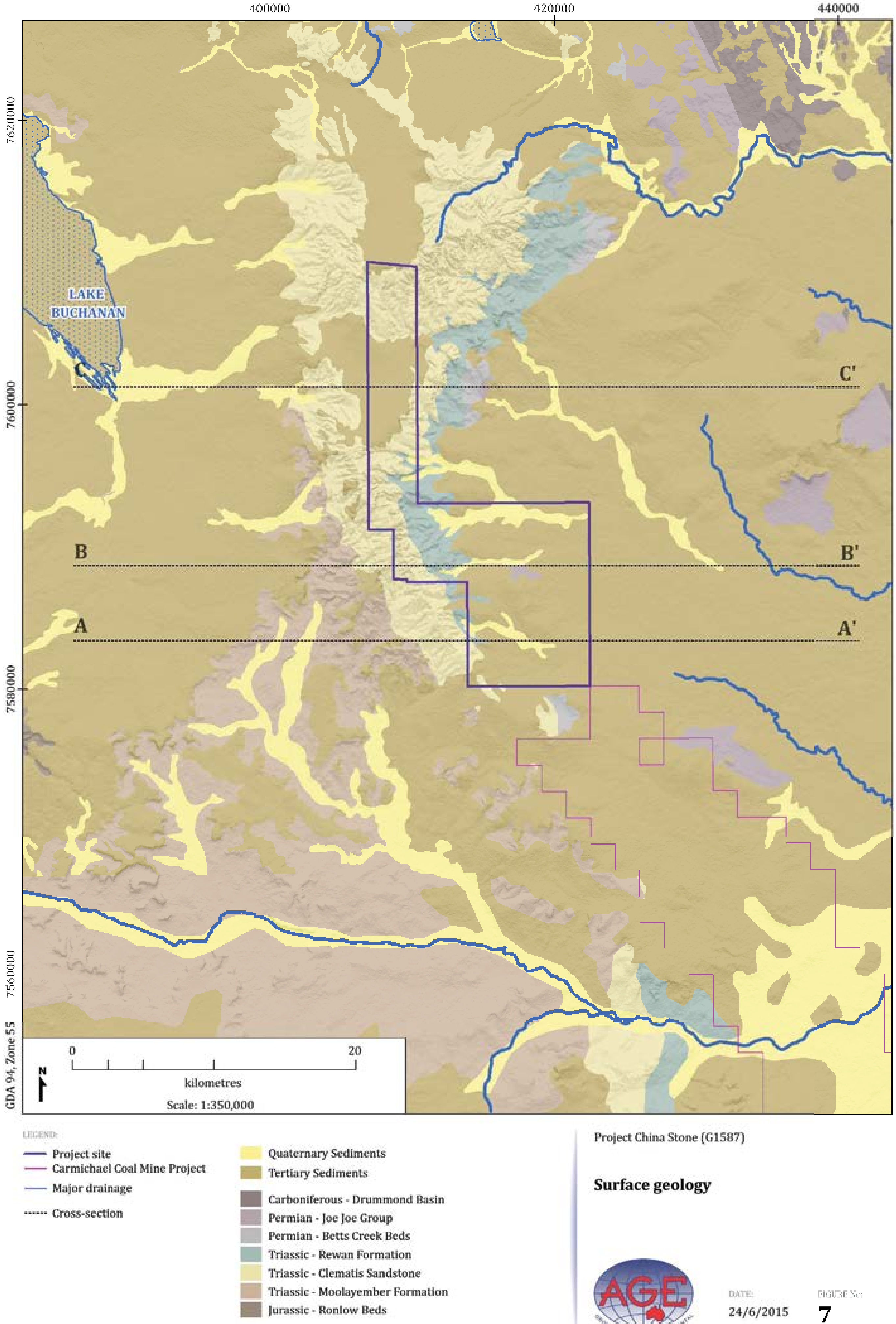
FIGURE No:
6



Project China Stone (G1587)

Surface geology

DATE: 24/6/2015

FIGURE No: 7

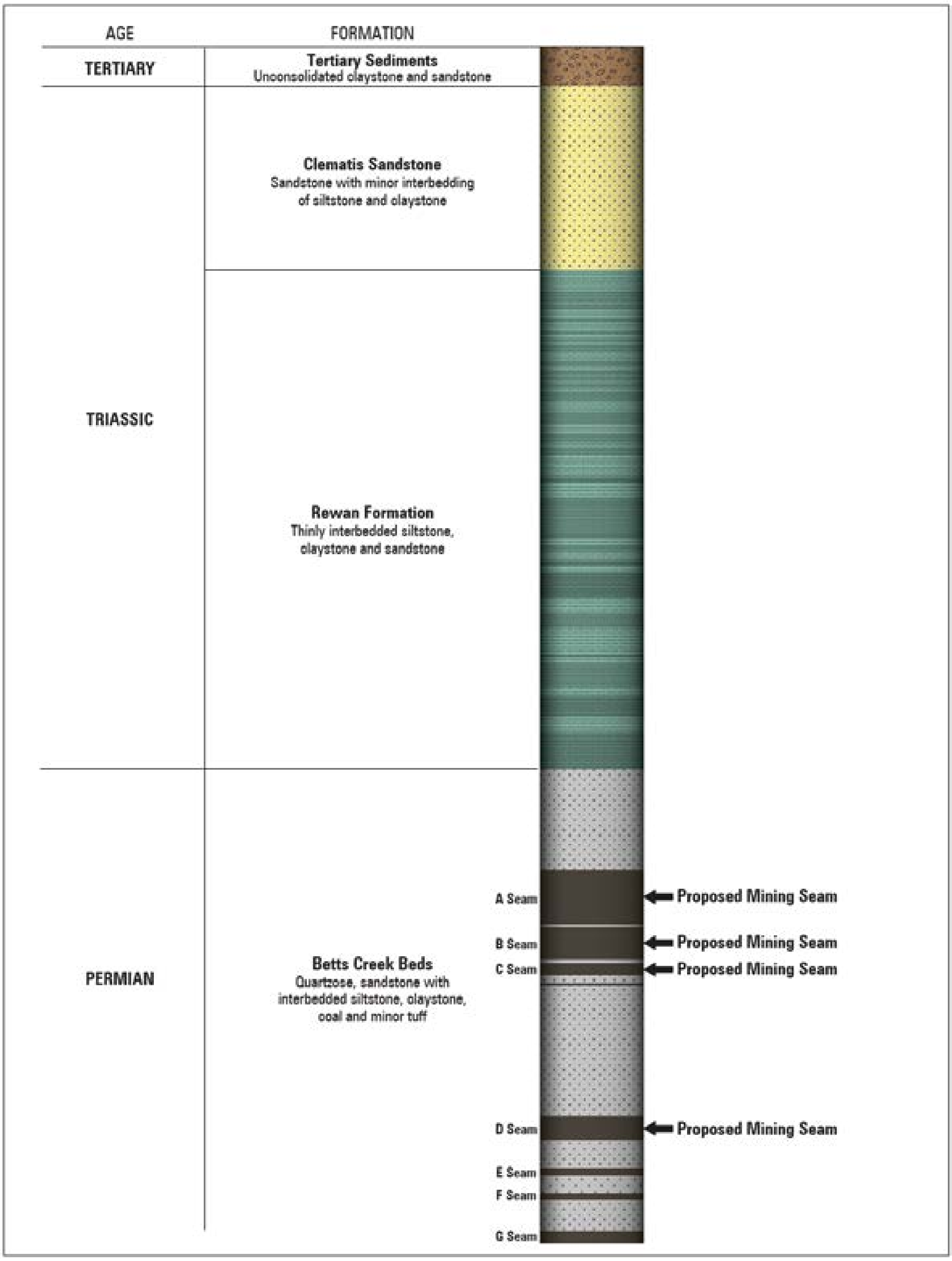


Figure 8 Stratigraphic column (source Hansen Bailey)

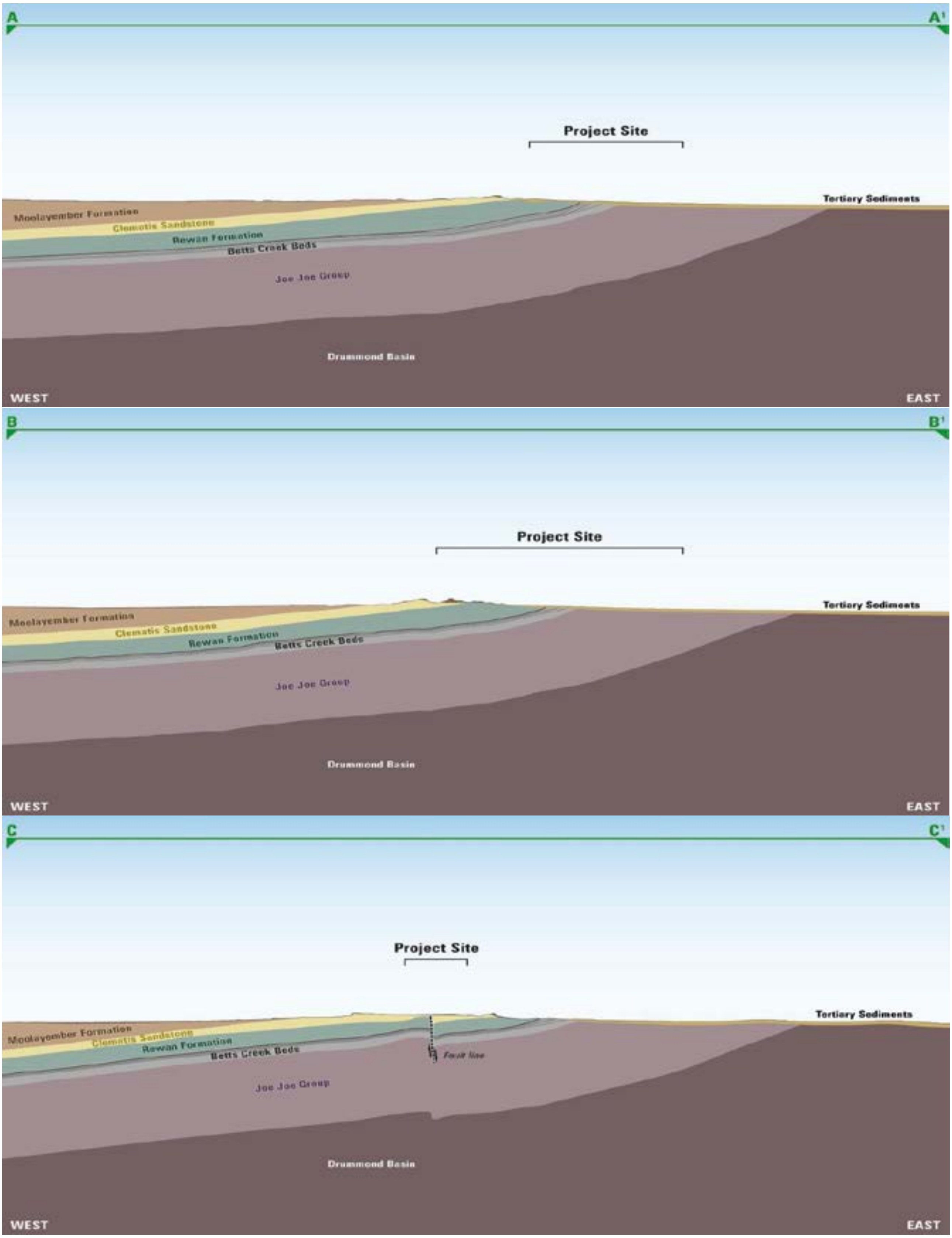
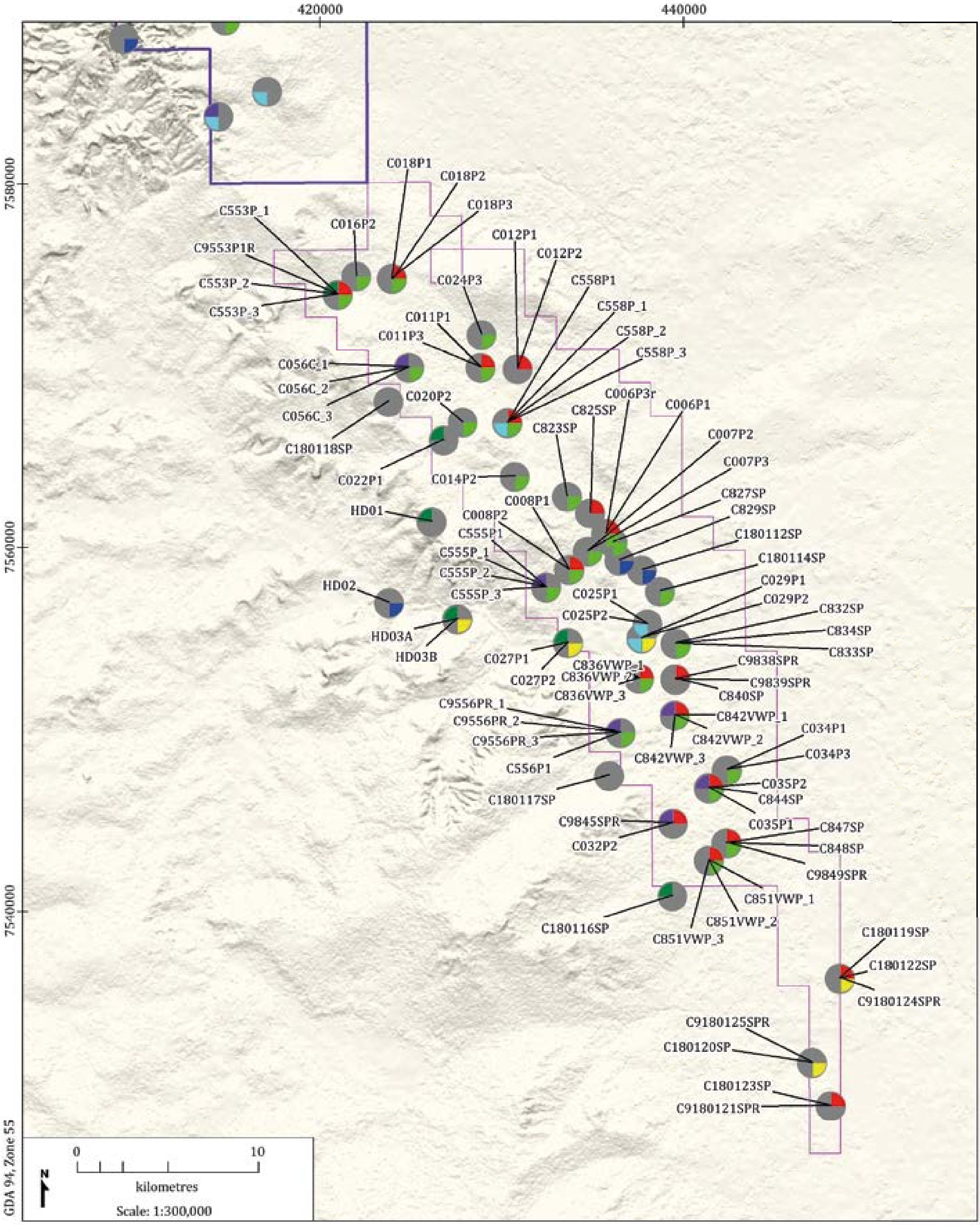


Figure 9 Geological Cross Sections (source Hansen Bailey)



LEGEND:

— Project site

— Carmichael Coal Mine Project

Monitoring bores by Geology

🟥 Betts Creek Beds Interburden

🟩 Betts Creek Beds Coal Seam

🟦 Clematis Sandstone

🟩 Dunda Beds

🟨 Quaternary Alluvium

🟪 Rewan Formation

🟦 Tertiary Sediments

Project China Stone (G1587)

Carmichael Coal Mine Monitoring Bores

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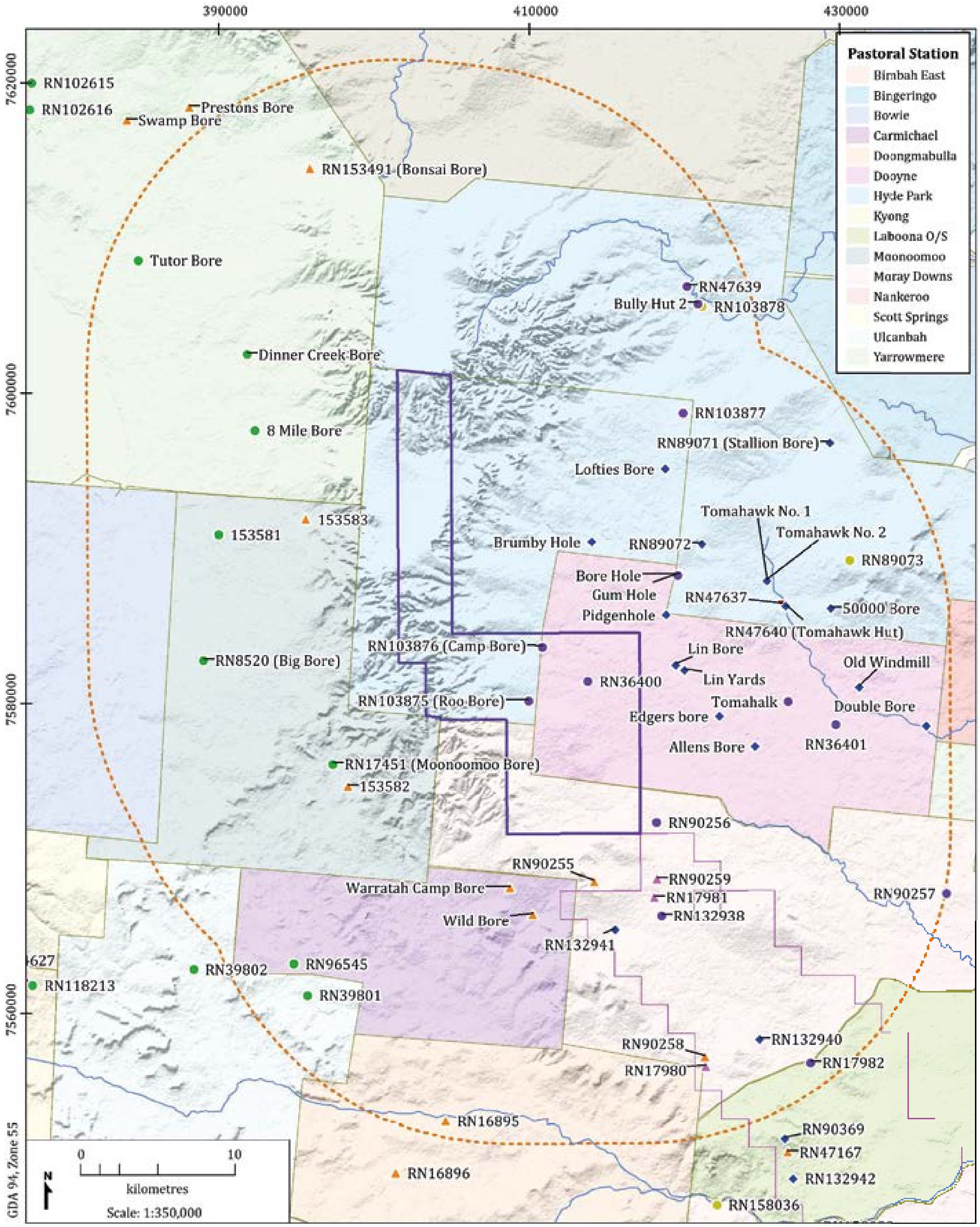
FIGURE No:
10



LEGEND:

Private bore by stratigraphy intersected:

- ● Quaternary Sediments
- ◆ Tertiary Sediments
- ● Moolayember Formation
- ● Dunda Beds
- ◆ Ronlow Beds
- ▲ Clematis Sandstone
- ▲ Rewan Formation
- ● Betts Creek Beds and Joe Joe Group
- ▼ Basement Volcanics

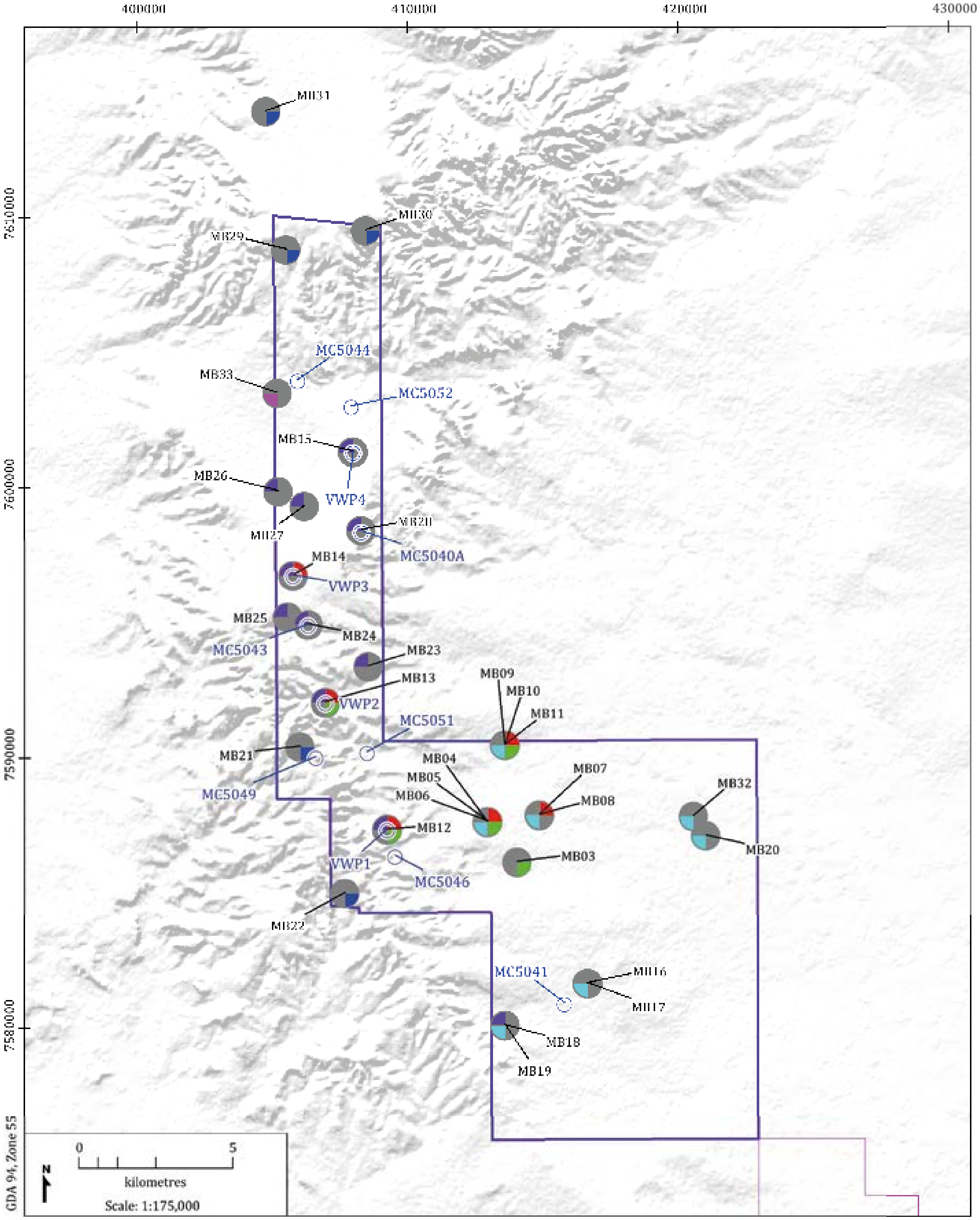
- Project site
- Carmichael Coal Mine Project
- Major drainage
- 10km from Project site
- 20km from Project site

Project China Stone (G1587)

Private Bores

DATE: 24/6/2015

FIGURE No: **11**



LEGEND:

Monitoring bores by Geology

🟥 Betts Creek Beds Interburden

🟩 Betts Creek Beds Coal Seam

🟦 Clematis Sandstone

○ Packer test completed

🟪 Clematis Sandstone / Rewan Fm

🟪 Rewan Formation

🟦 Tertiary Sediments

— Project site

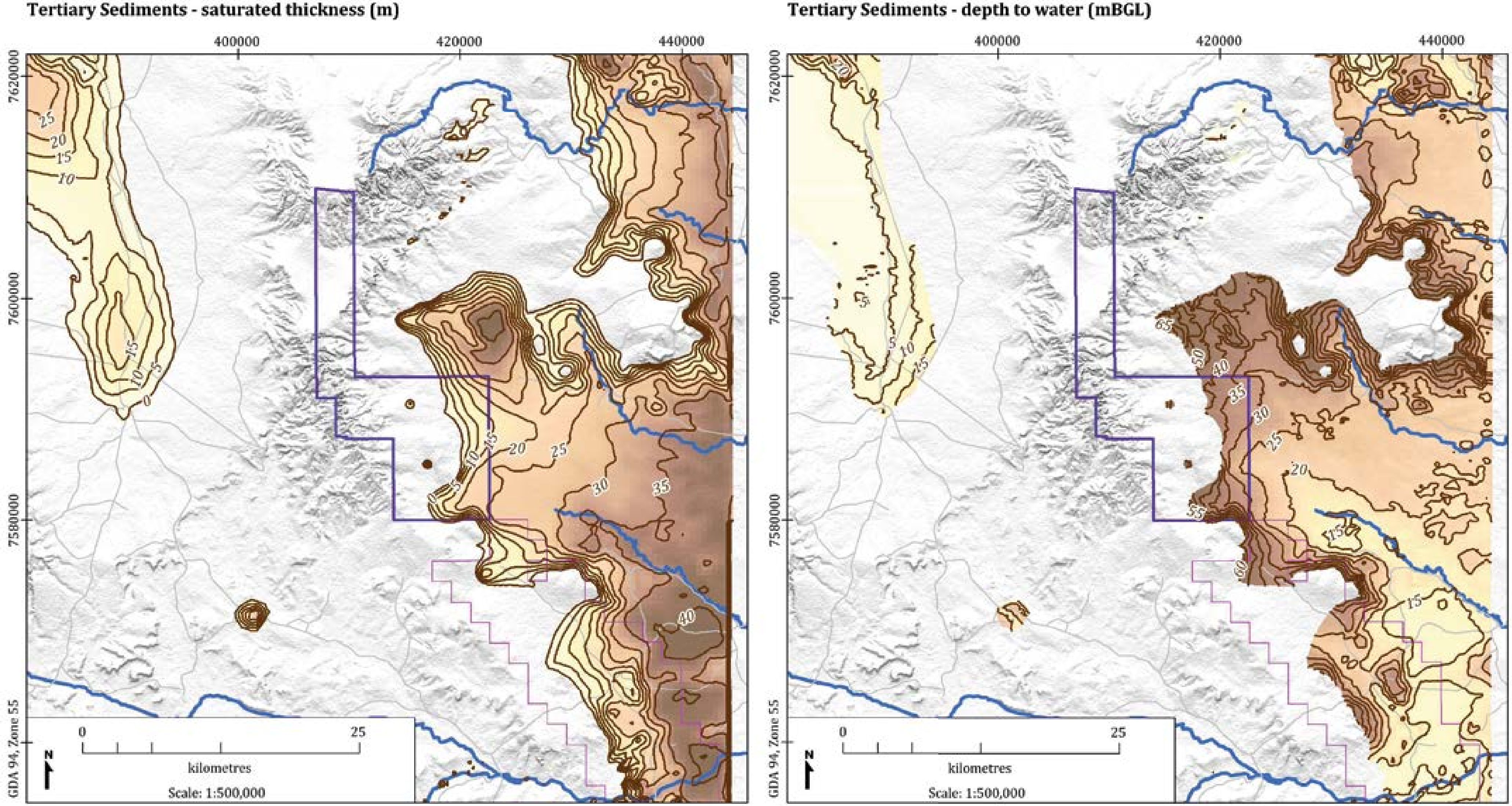
— Carmichael Coal Mine Project

Project China Stone (G1587)

Field investigation bores

DATE: 24/6/2015

FIGURE No: 12



LEGEND:

saturated thickness (5m interval, m)
Depth to water (5m interval, mBGL)

Project site

Carmichael Coal Mine Project

Project China Stone (G1587)

Tertiary Sediments - saturated thickness and depth to potentiometric surface

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FIGURE No:
13

Figure 14 VWP hydrographs

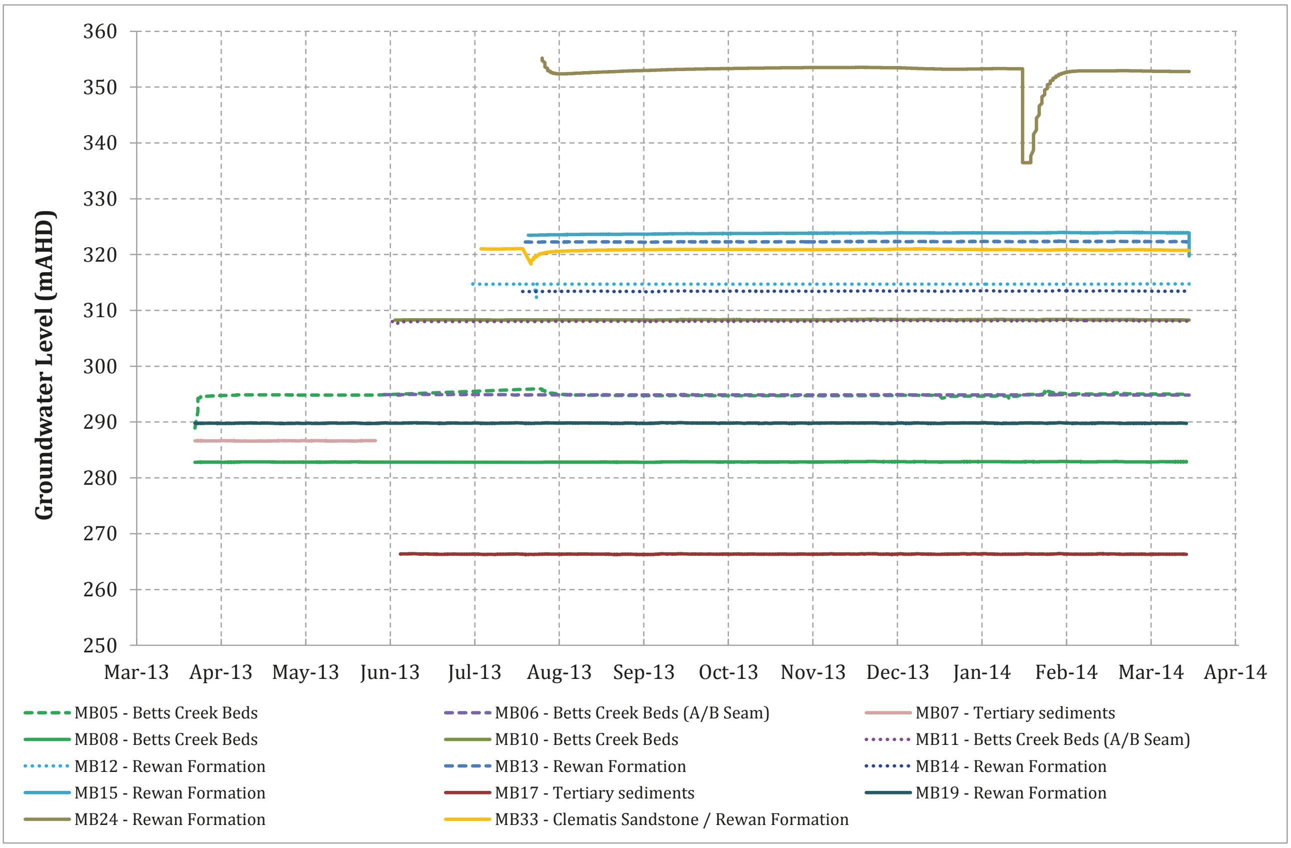
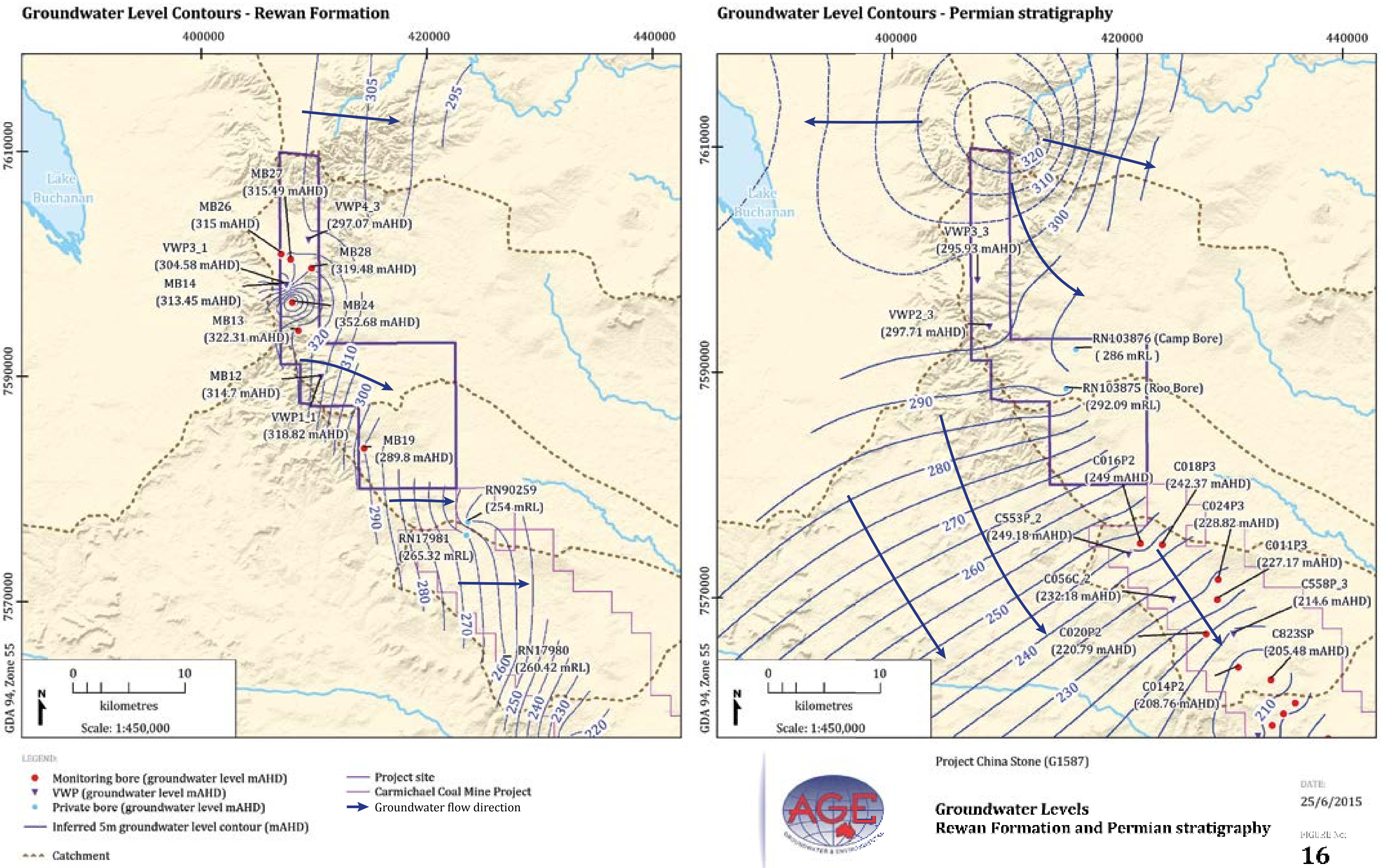


Figure 15 **Groundwater level hydrographs**



Project China Stone (G1587)

Groundwater Levels
Rewan Formation and Permian stratigraphy

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FIGURE No:
16

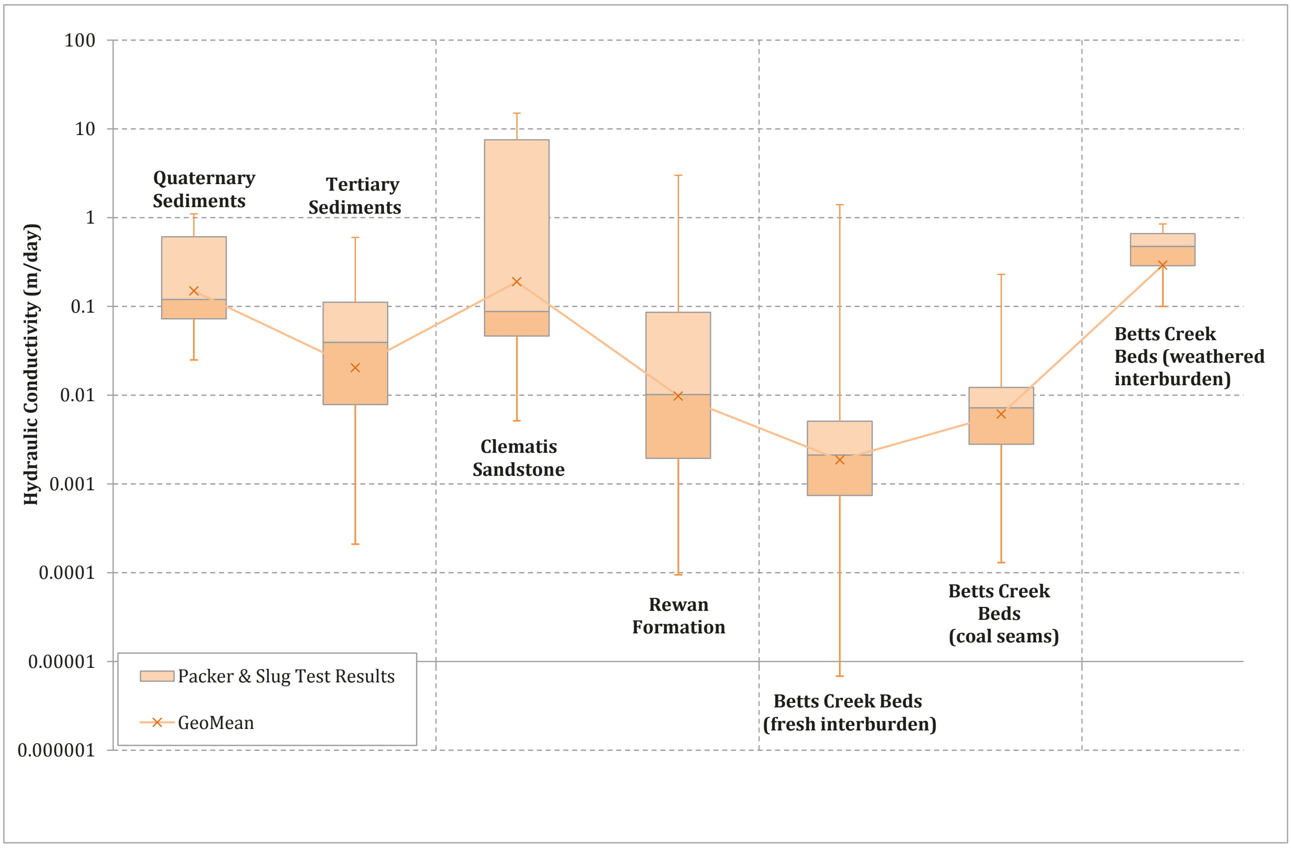


Figure 17 Hydraulic conductivity data

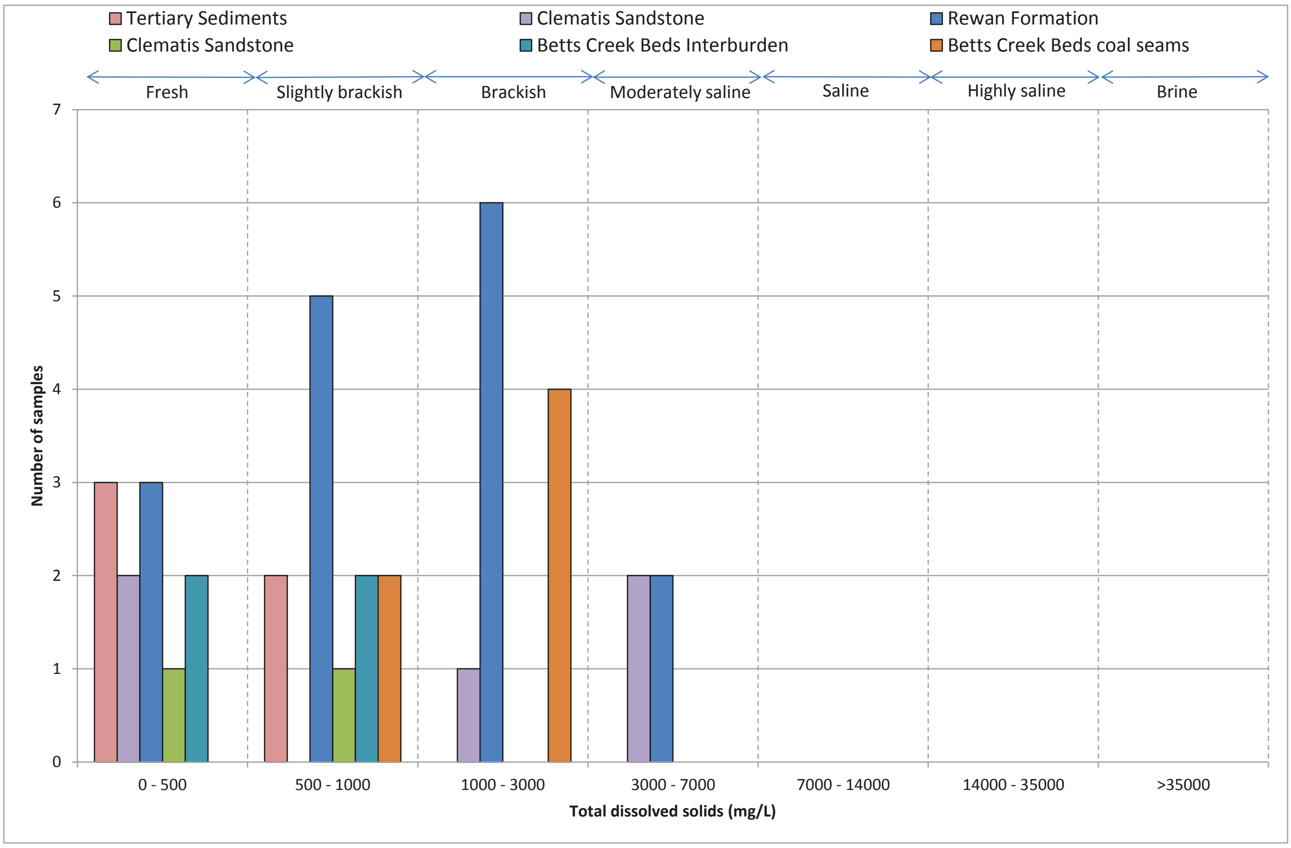
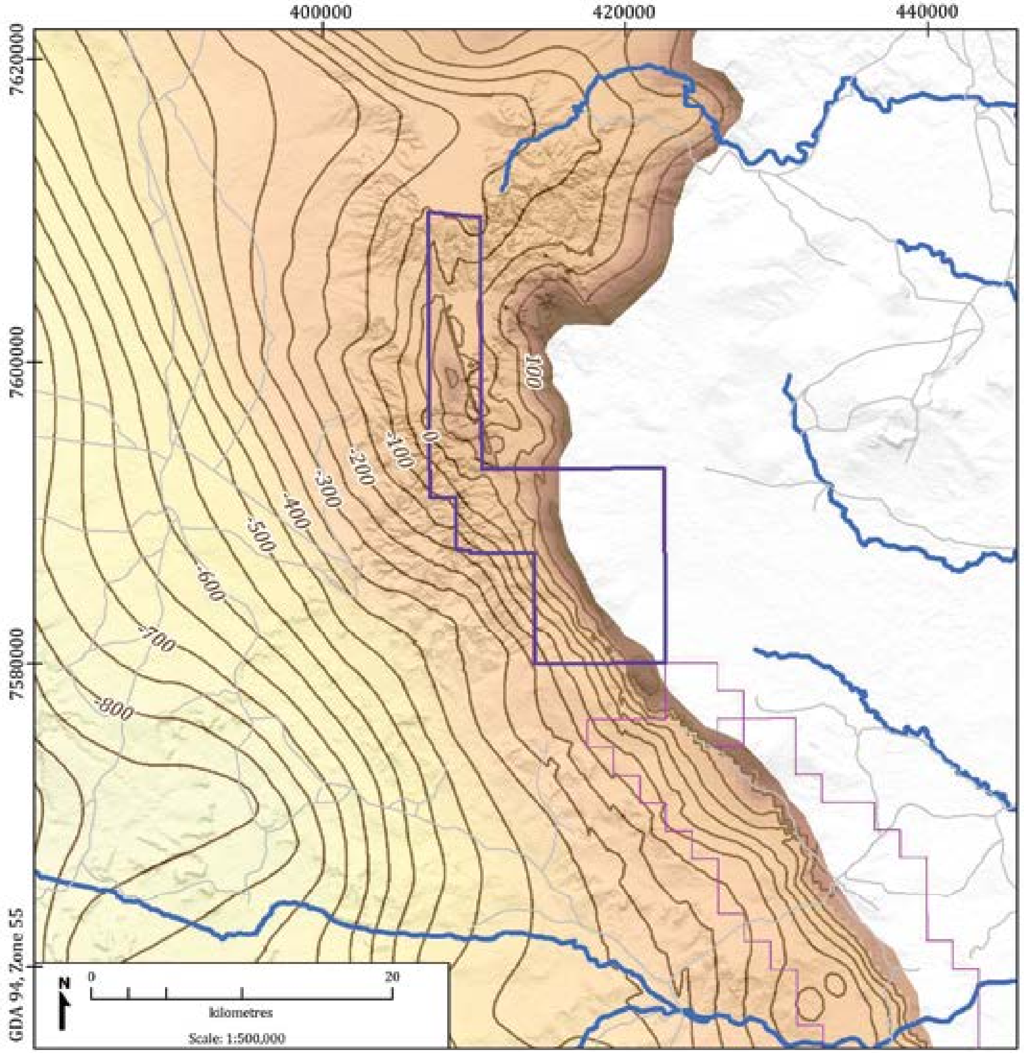
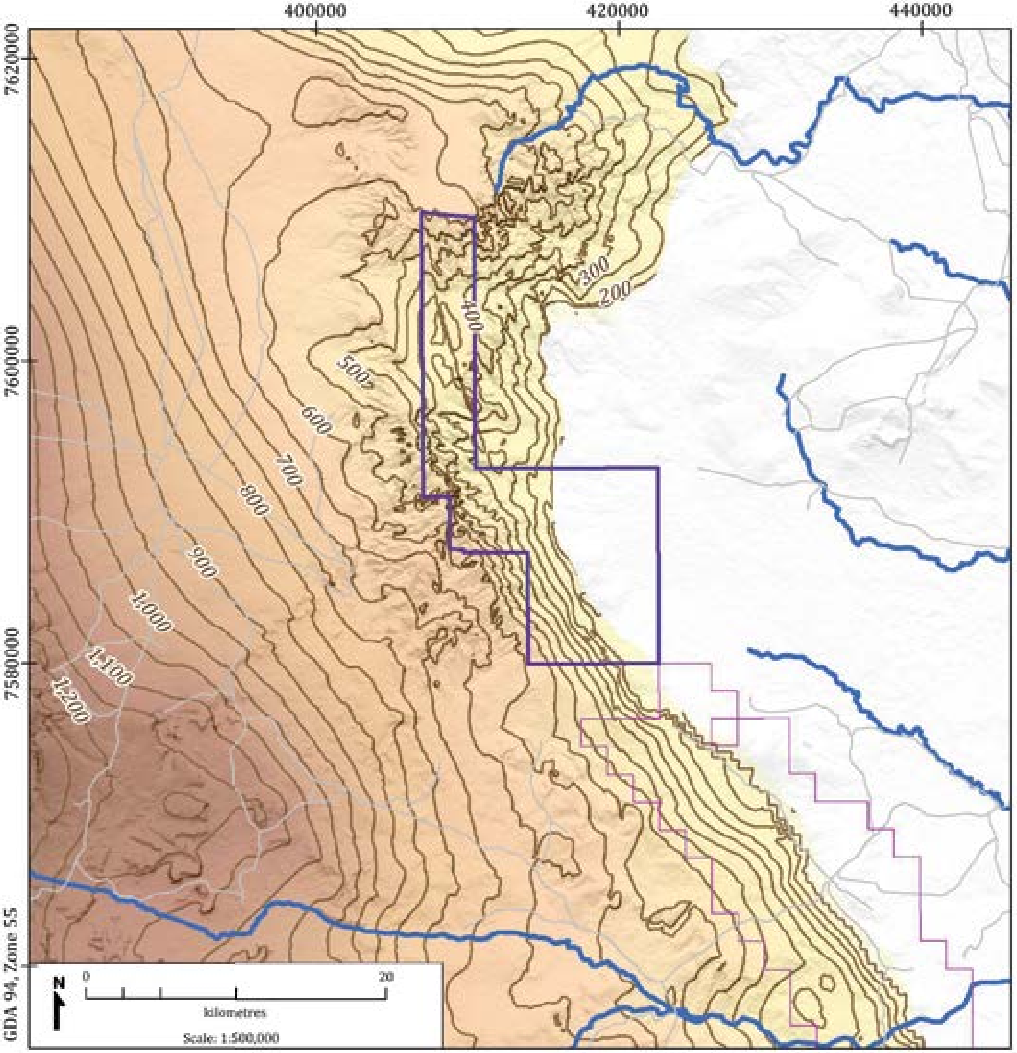


Figure 18 TDS Histogram – all geological units

Permian Betts Creek Beds - structure of base (mAHD)



Permian Betts Creek Beds - depth to base (mBGL)



LEGEND:

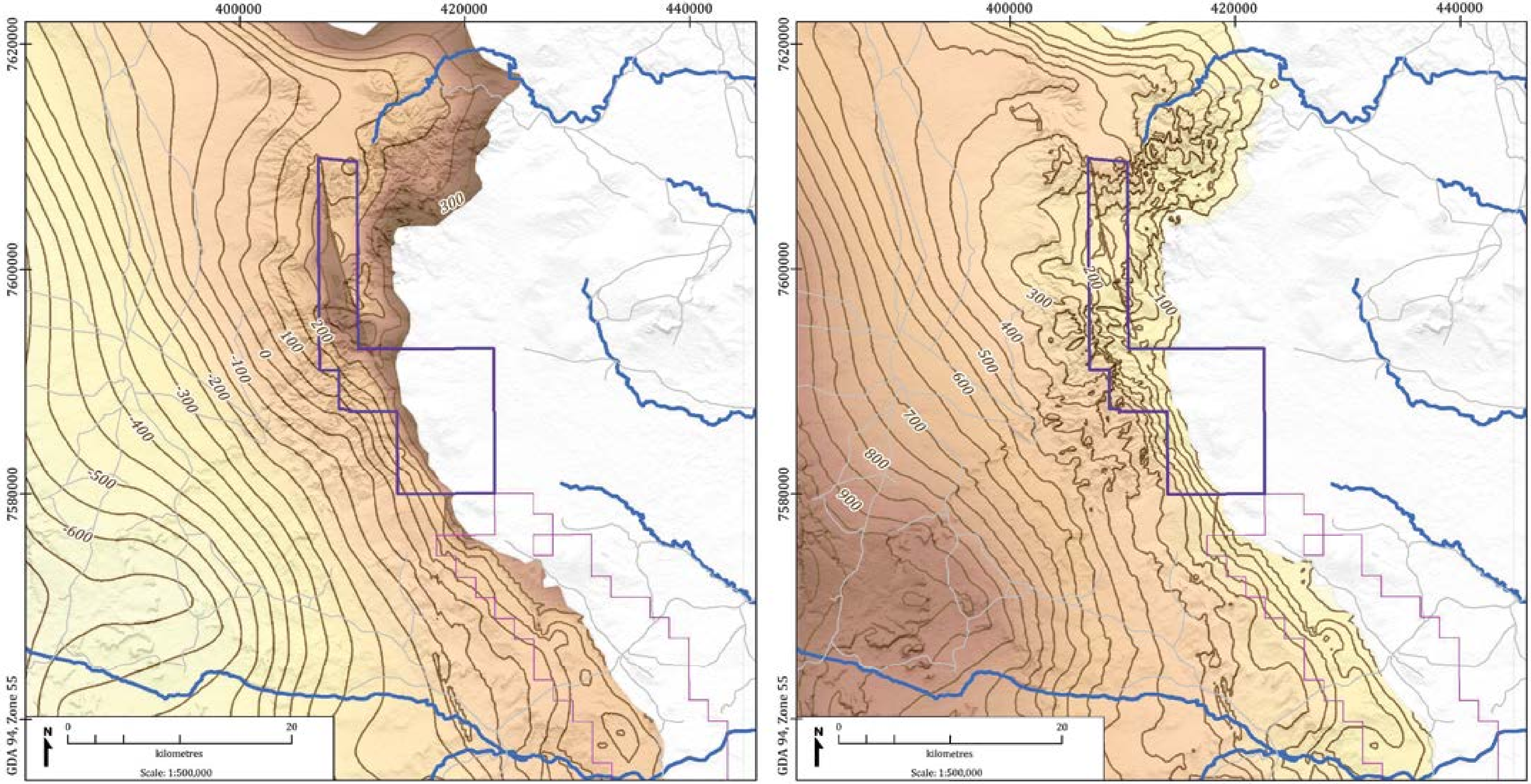
- Structure of base contour (50m interval, mAHD)
  Depth to base contour (50m interval, mBGL)
- Project site
- Carmichael Coal Mine Project

Project China Stone (G1587)

Permian Betts Creek Beds - structure of base and depth to base

DATE:
24/6/2015

FIGURE No:
19



Rewan Formation - structure of base (mAHD)

Rewan Formation - depth to base (mBGL)

LEGEND:

Structure of base contour (50m interval, mAHD)
Depth to base contour (50m interval, mBGL)

Project site

Carmichael Coal Mine Project

Project China Stone (G1587)

Rewan Formation - structure of base and depth to base

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24/6/2015

FIGURE No:
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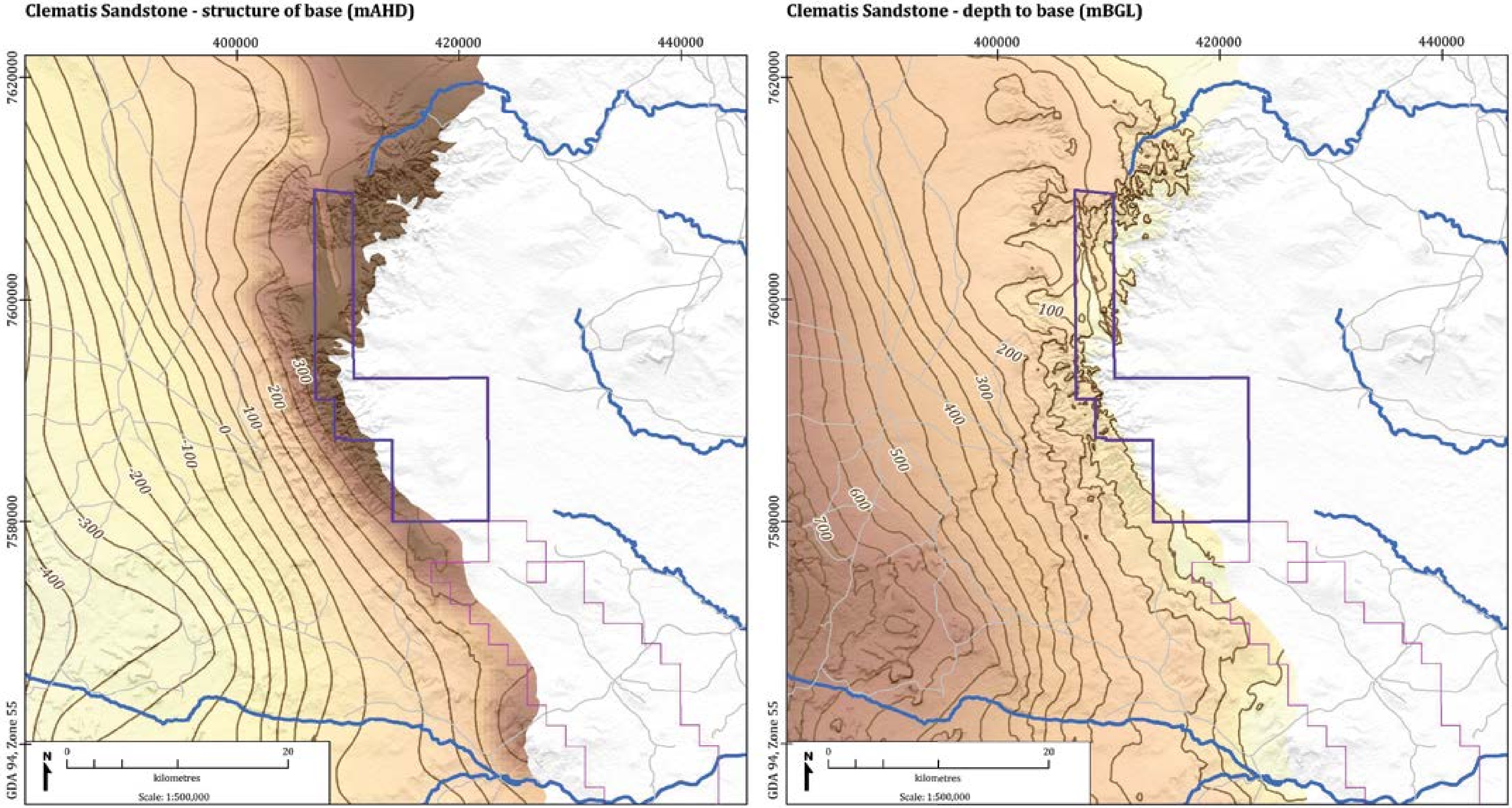

LEGEND:

Structure of base contour (50m interval, mAHD)
Depth to base contour (50m interval, mBGL)

Project site

Carmichael Coal Mine Project

Project China Stone (G1587)

Clematis Sandstone - structure of base and depth to base

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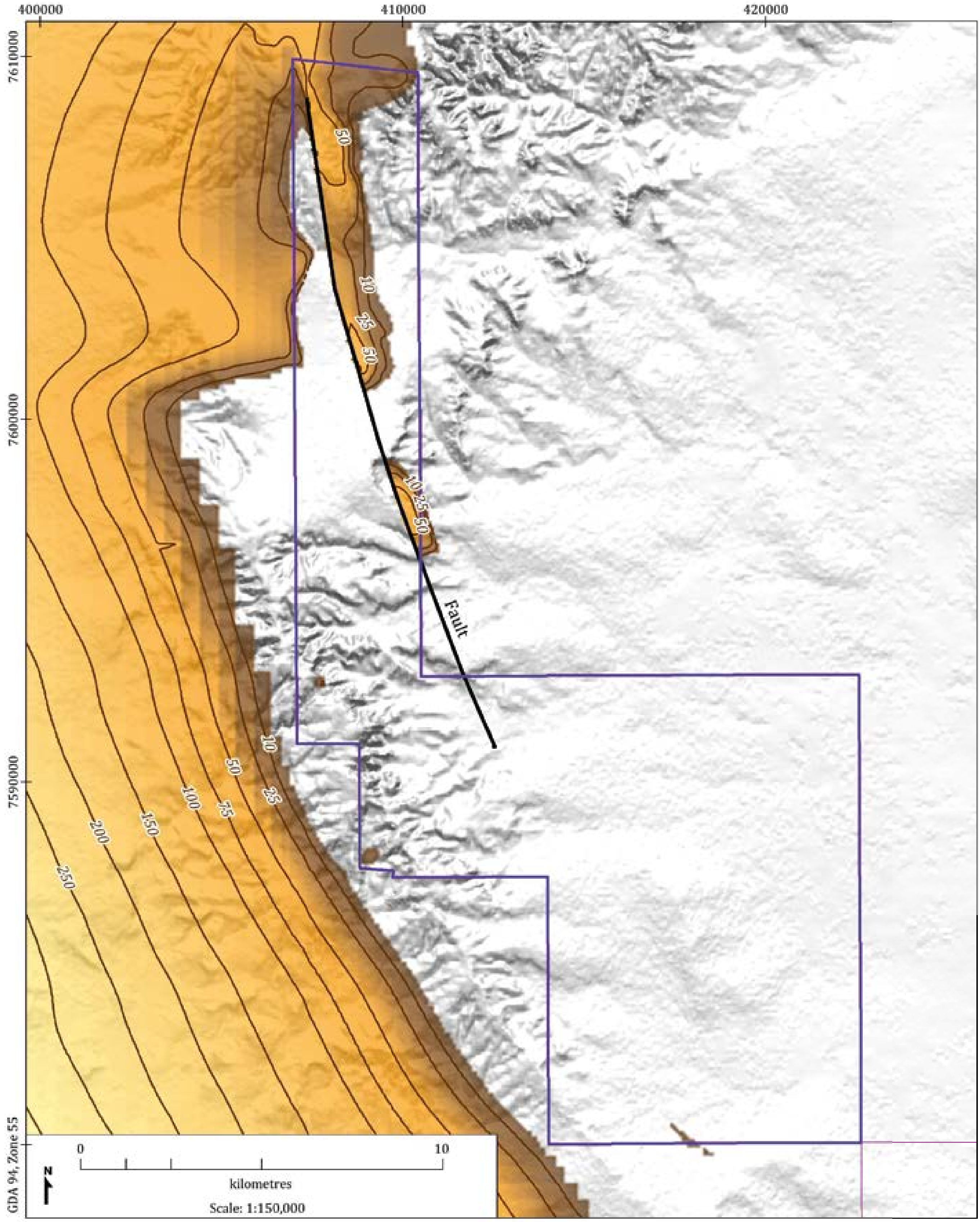
FIGURE No:
21



LEGEND:

— Contours

— Fault

— Project site

— Carmichael Coal Mine Project

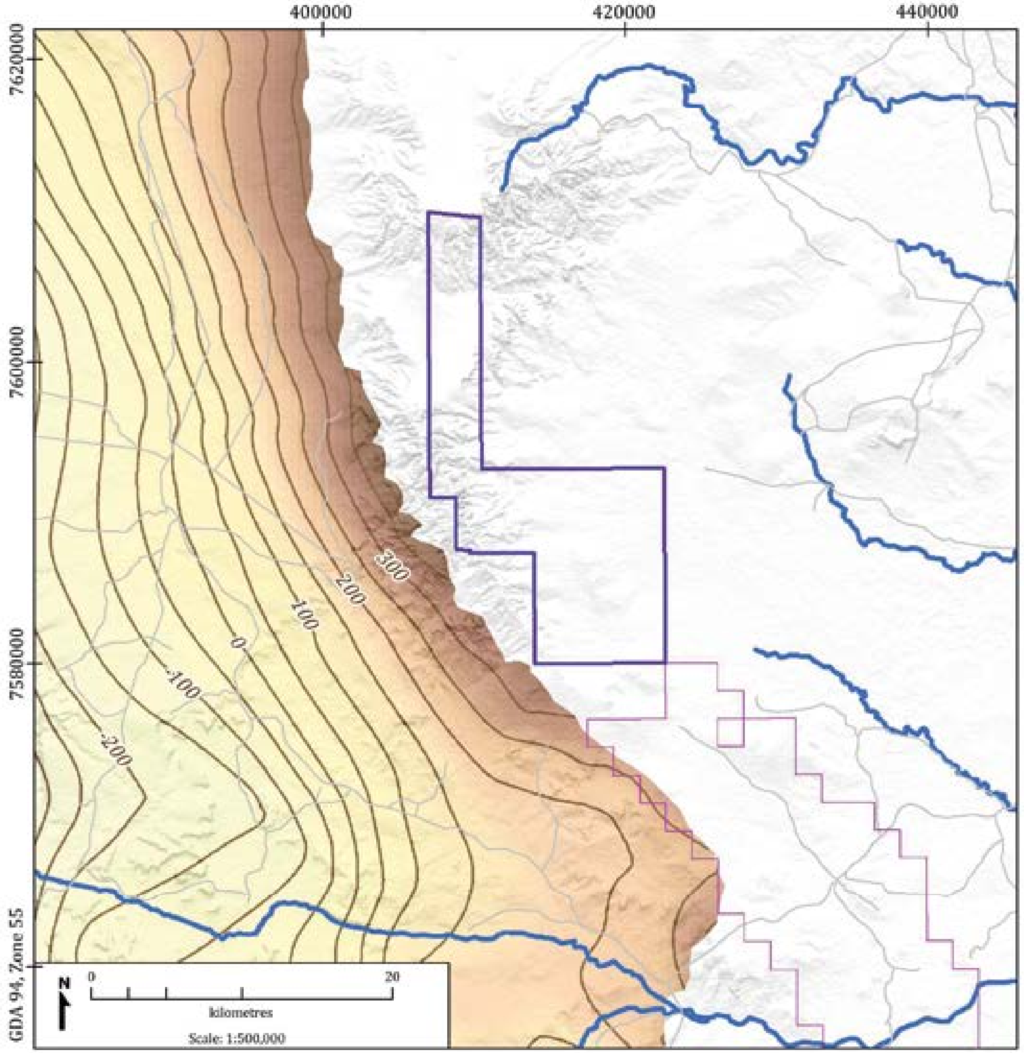
Project China Stone (G1587)

Saturated thickness of Clematis Sandstone

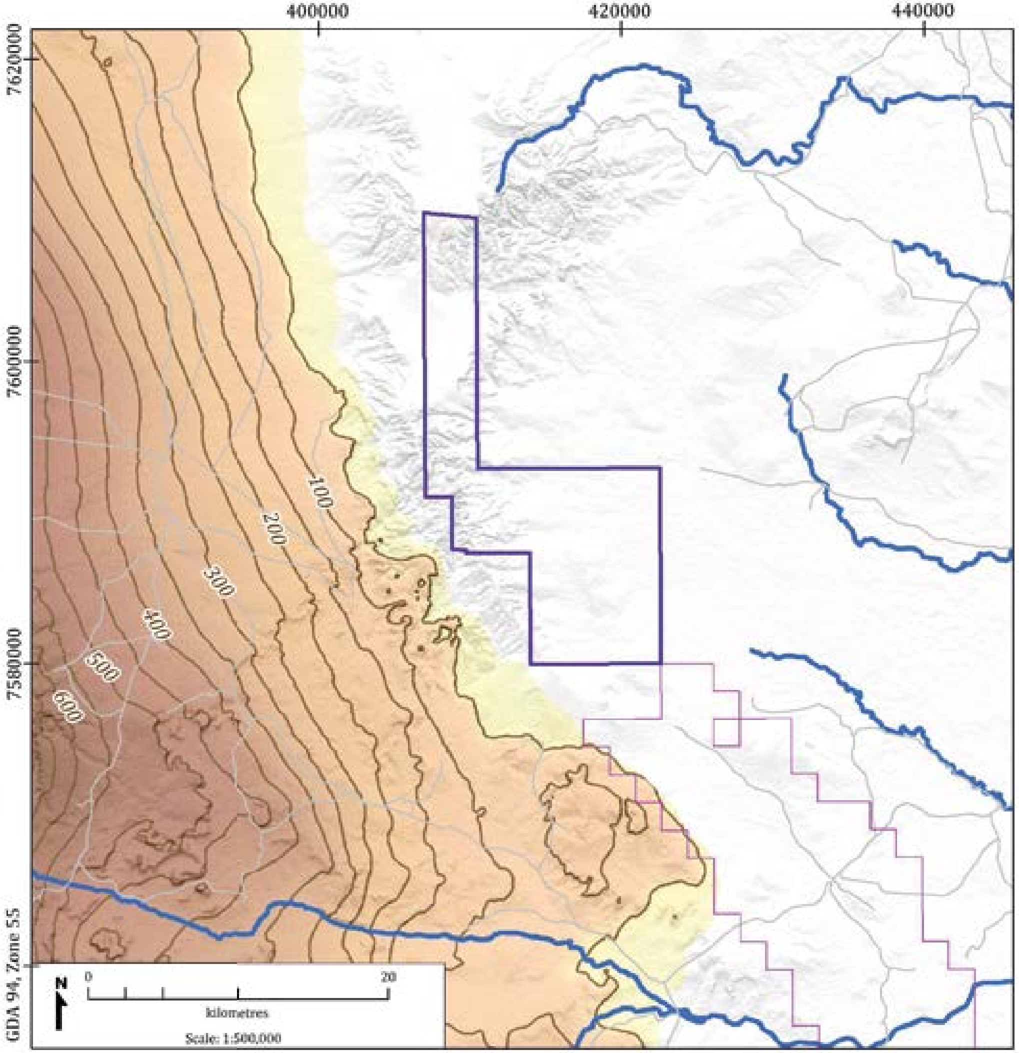
DATE: 24/6/2015

FIGURE No: 22

Moolayember Formation - structure of base (mAHD)



Moolayember Formation - depth to base (mBGL)



LEGEND:

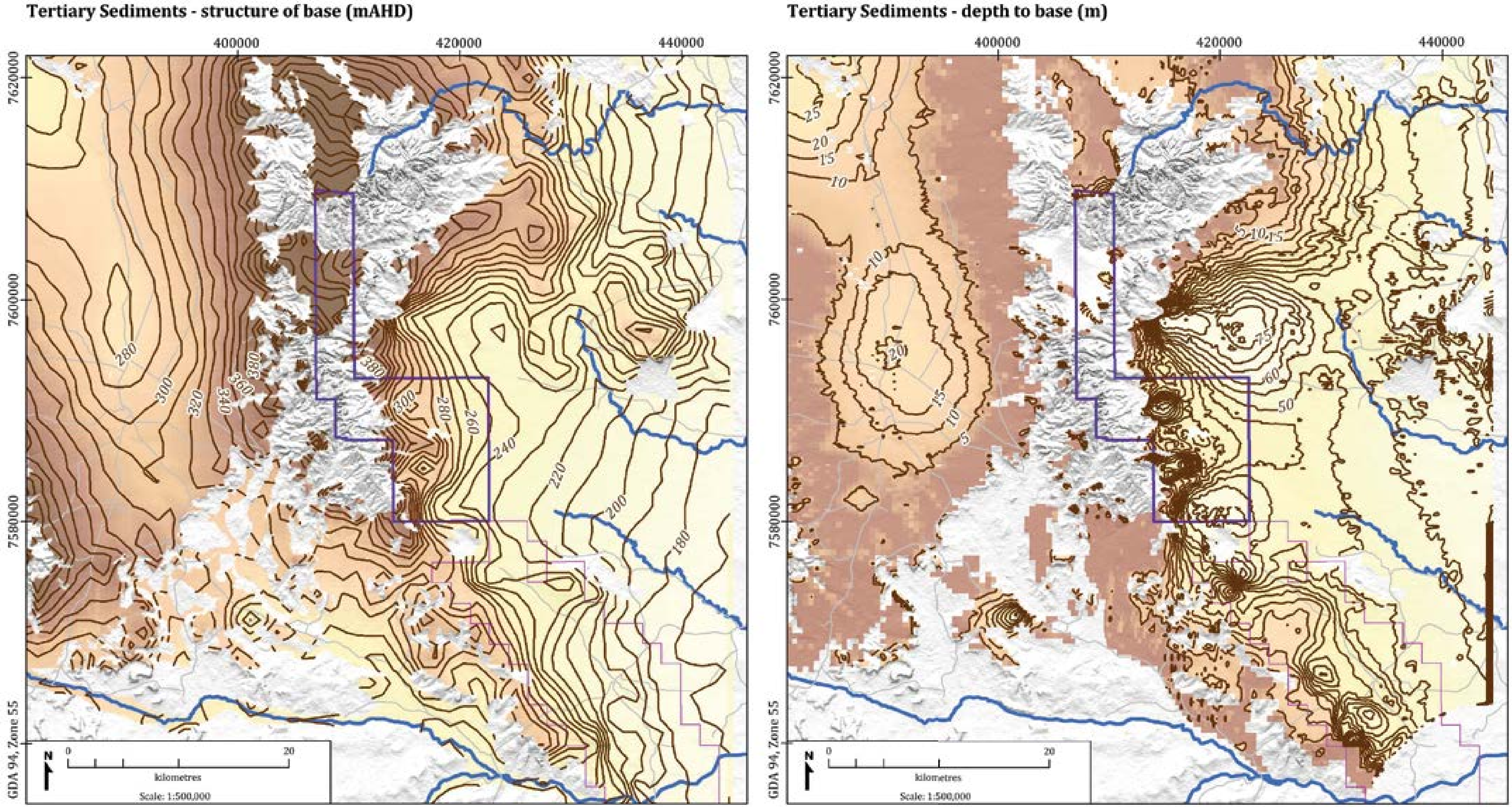
- Structure of base contour (50m interval, mAHD)
  Depth to base contour (50m interval, mBGL)
- Project site
- Carmichael Coal Mine Project

Project China Stone (G1587)

Moolayember Formation - structure of base and depth to base

DATE:
24/6/2015

FIGURE No:
23



Tertiary Sediments - structure of base (mAHD)

Tertiary Sediments - depth to base (m)

LEGEND:

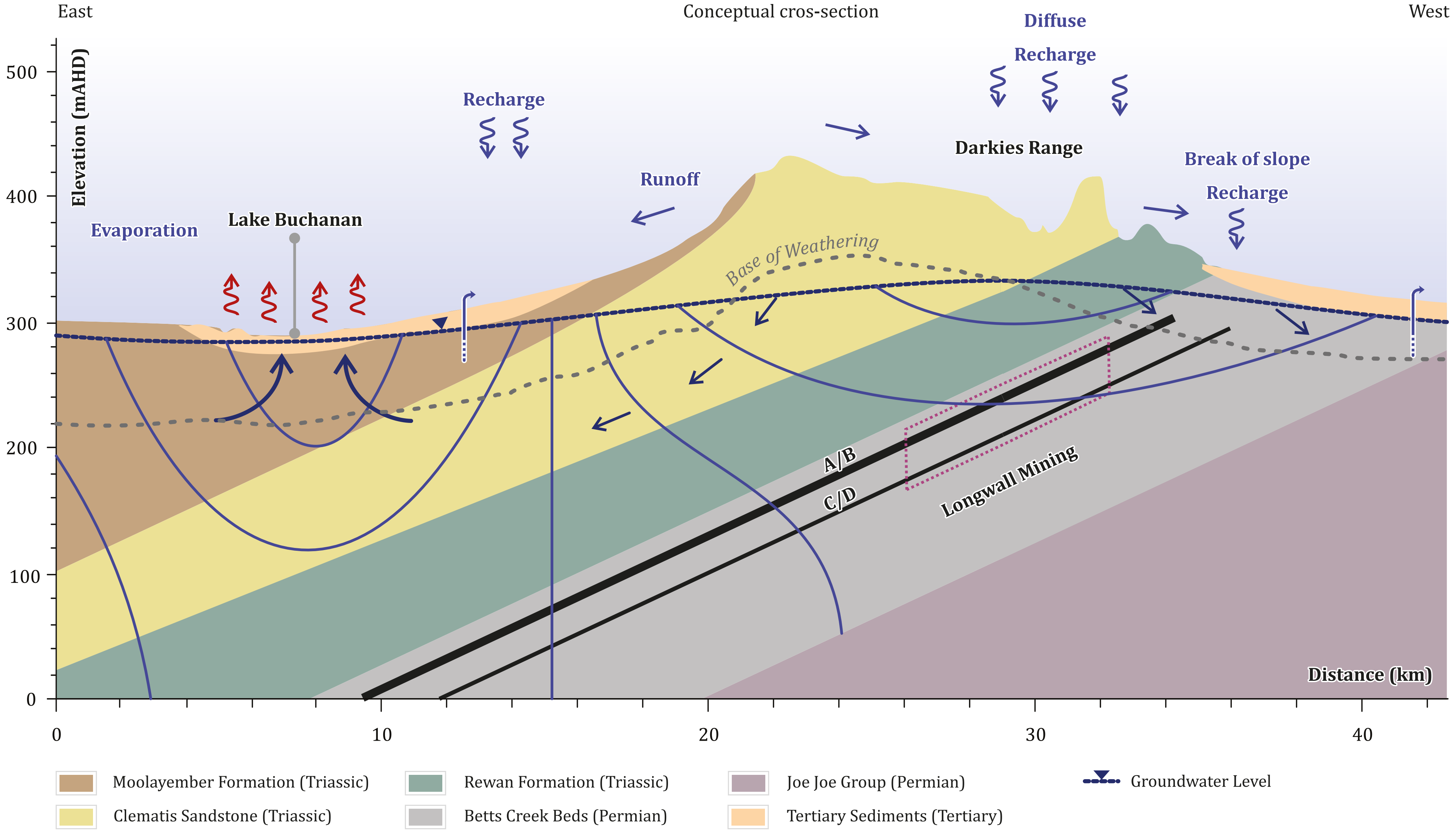
Structure of base contour (10m interval, mAHD)
Depth to base contour (5m interval, m)
Project site
Carmichael Coal Mine Project

Project China Stone (G1587)

Tertiary Sediments - structure of base and depth to base

DATE:
24/6/2015

FIGURE No:
24



Conceptual groundwater regime

Figure 25

Project China Stone (G1587)

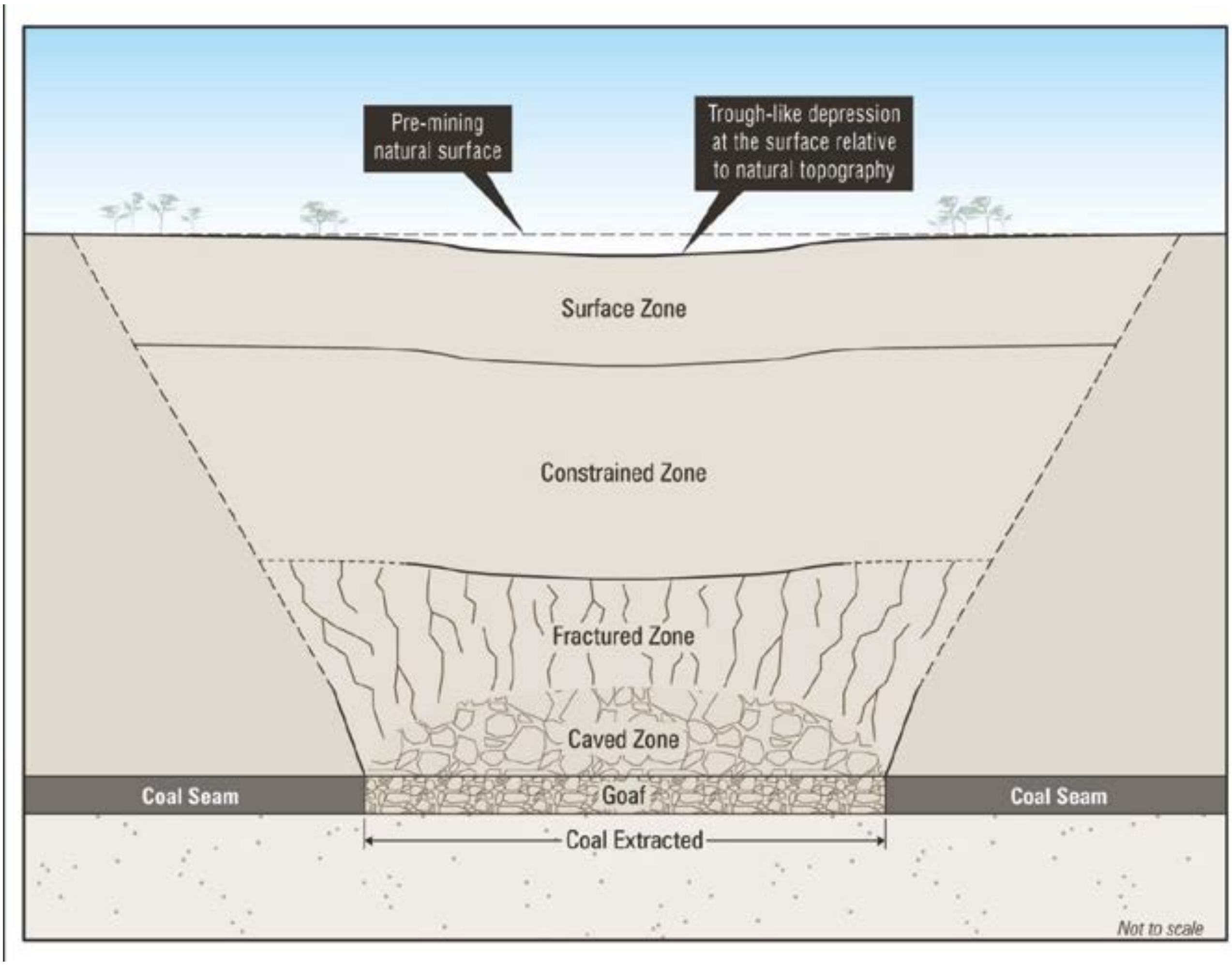
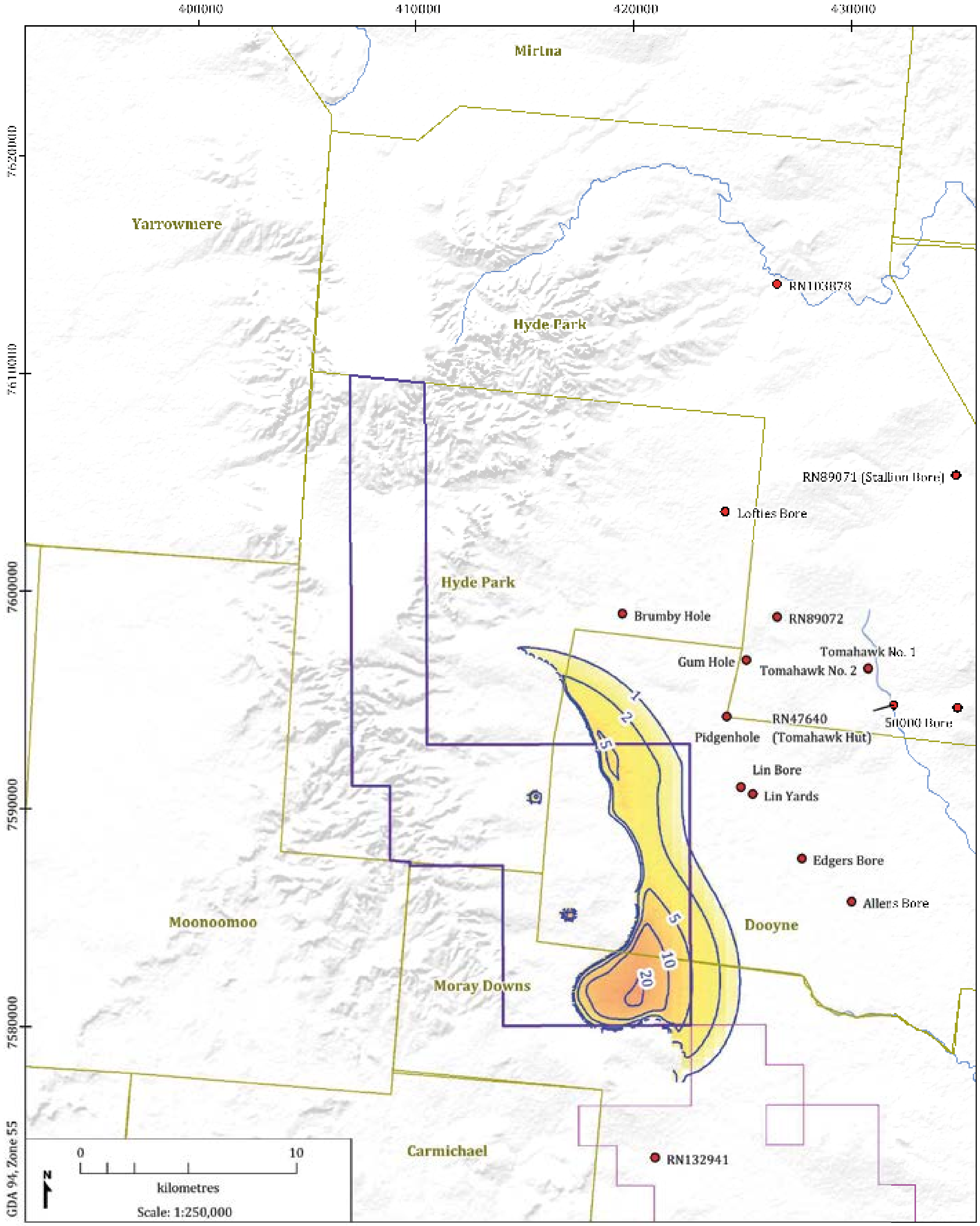


Figure 26 Conceptual model of caving and the nature of fracturing above a mine excavation (source Hansen Bailey)



Project China Stone (G1587)

Maximum zone of depressurisation during mining - Tertiary Sediments

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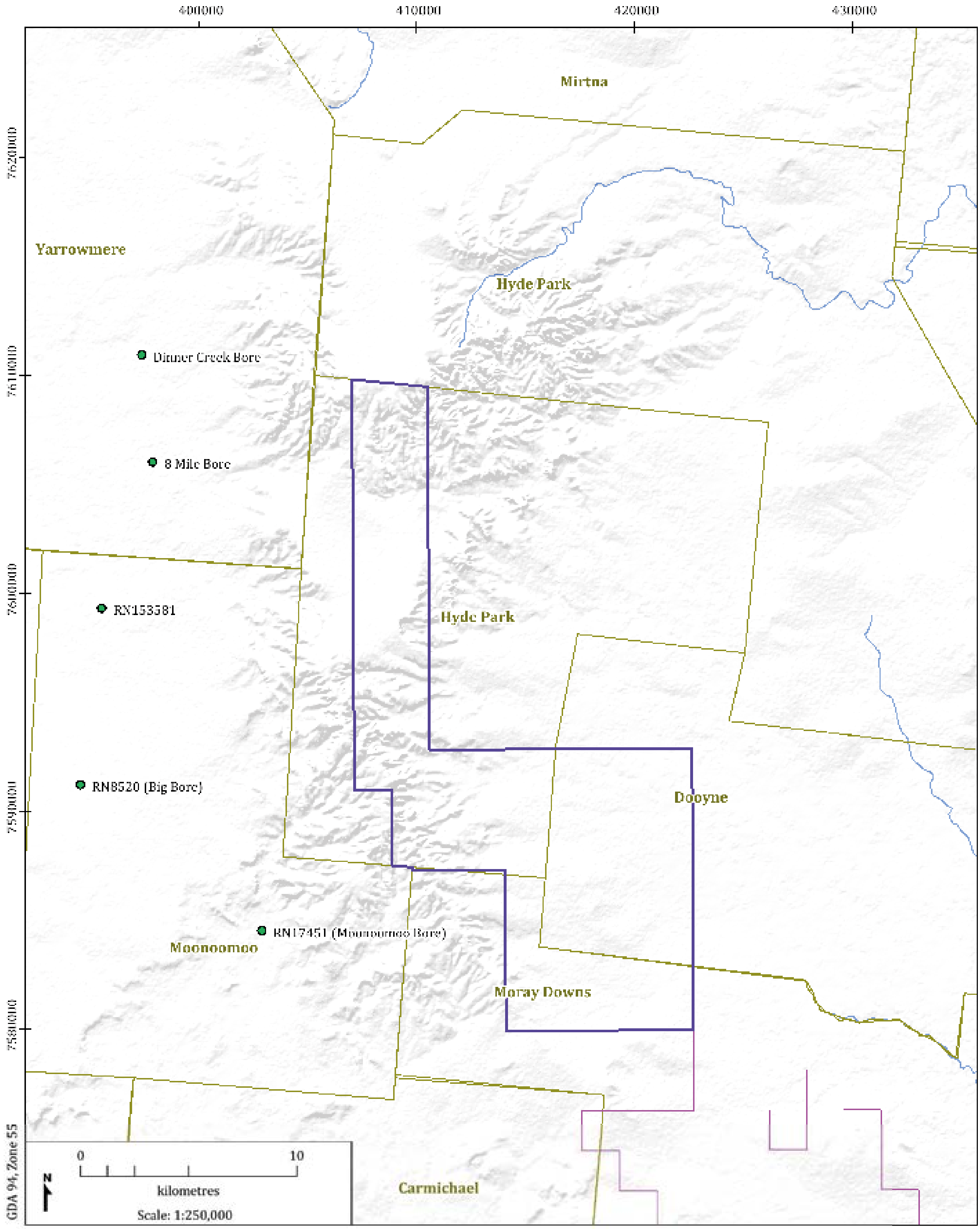
FIGURE No:
27



LEGEND:

(No contour for this layer)

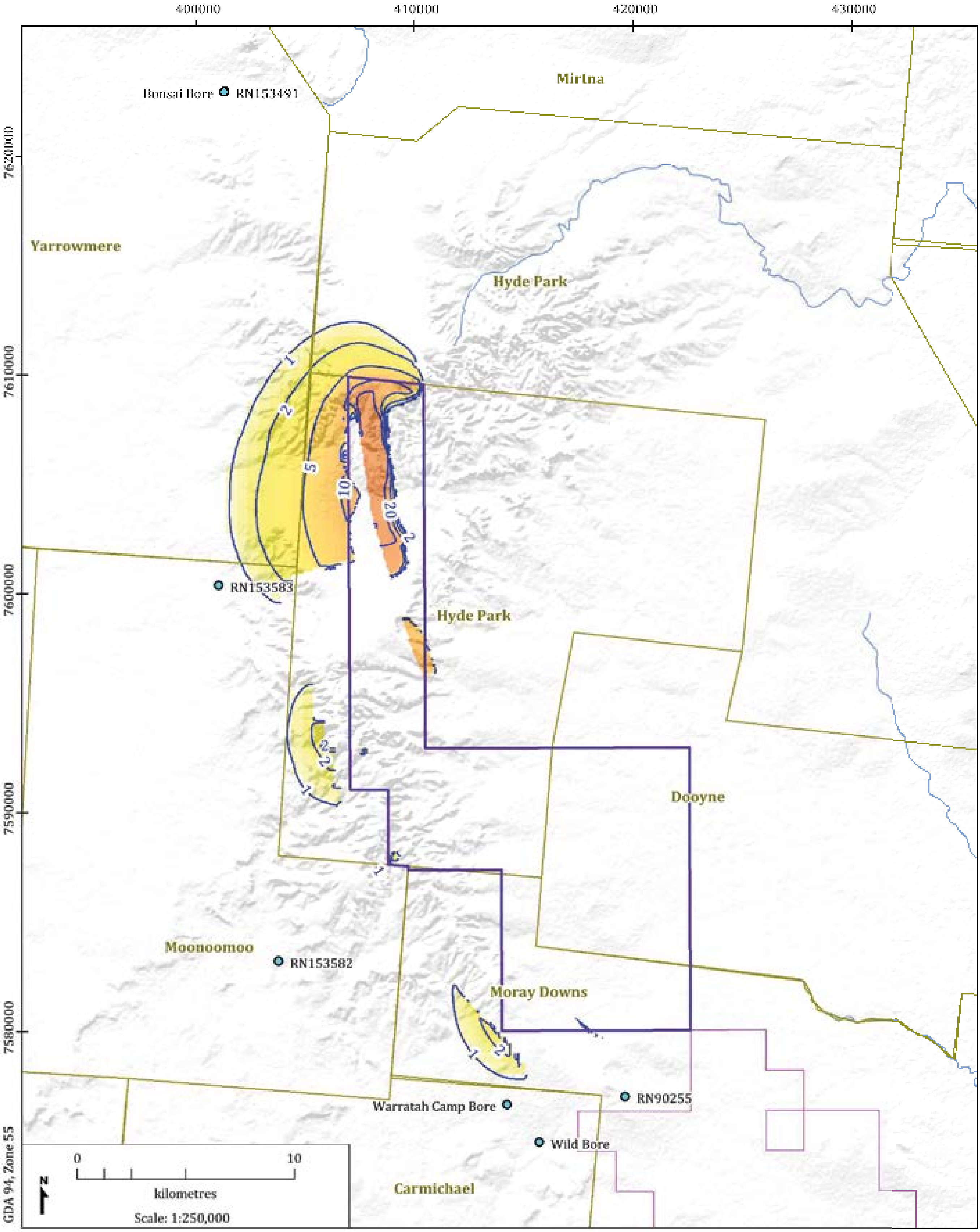
- ● Private bore
- — Project site
- — Carmichael Coal Mine Project
- — Major drainage
- ☐ Cadastre

Project China Stone (G1587)

Maximum zone of depressurisation during mining - Moolayember Formation

DATE: 24/6/2015

FIGURE No: **28**



LEGEND:

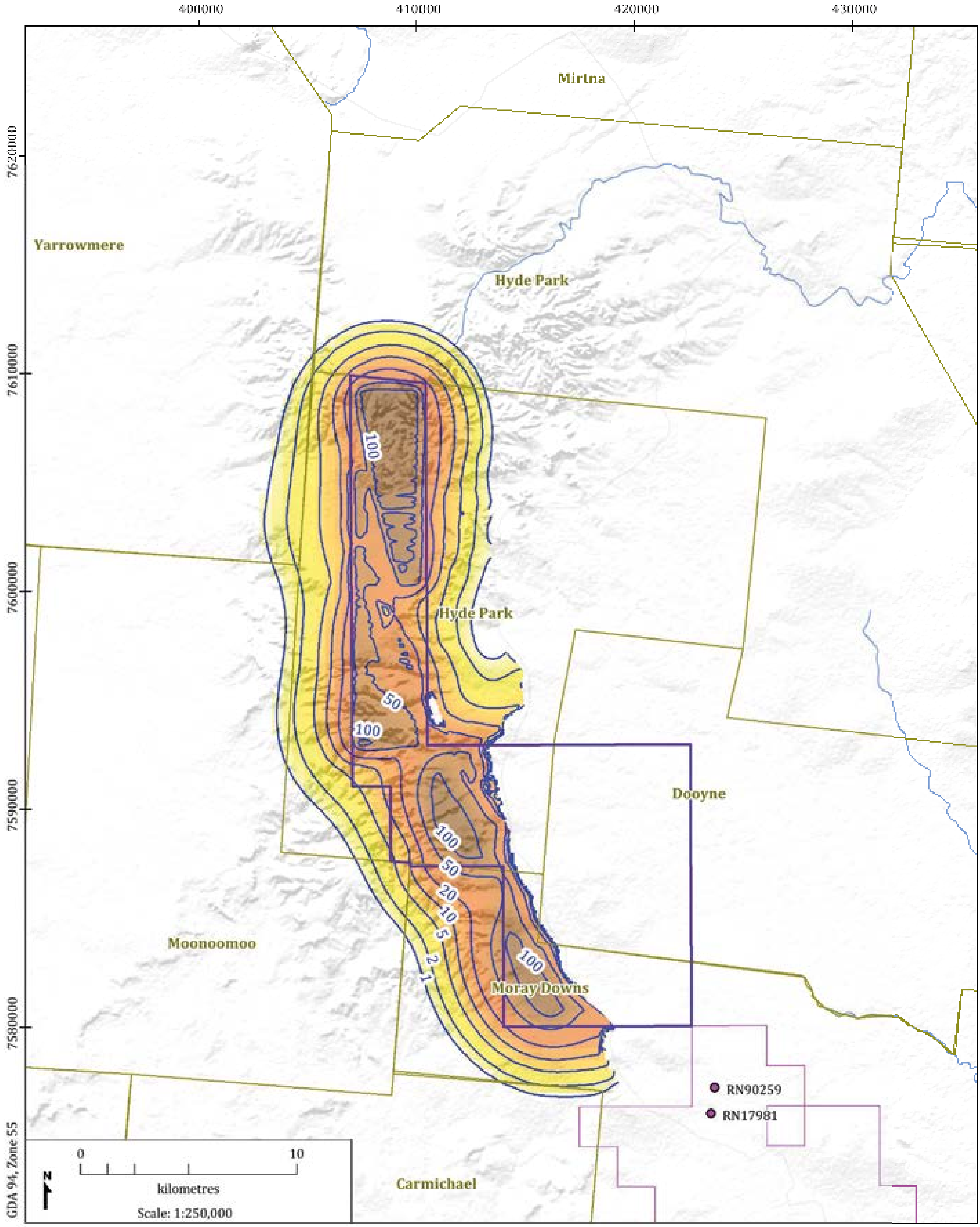
—	Maximum Drawdown contour (m)
●	Private bore
—	Project site
—	Carmichael Coal Mine Project
—	Major drainage
☐	Cadastre

Project China Stone (G1587)

Maximum zone of depressurisation during mining - Clematis Sandstone

DATE: 24/6/2015

FIGURE No: 29



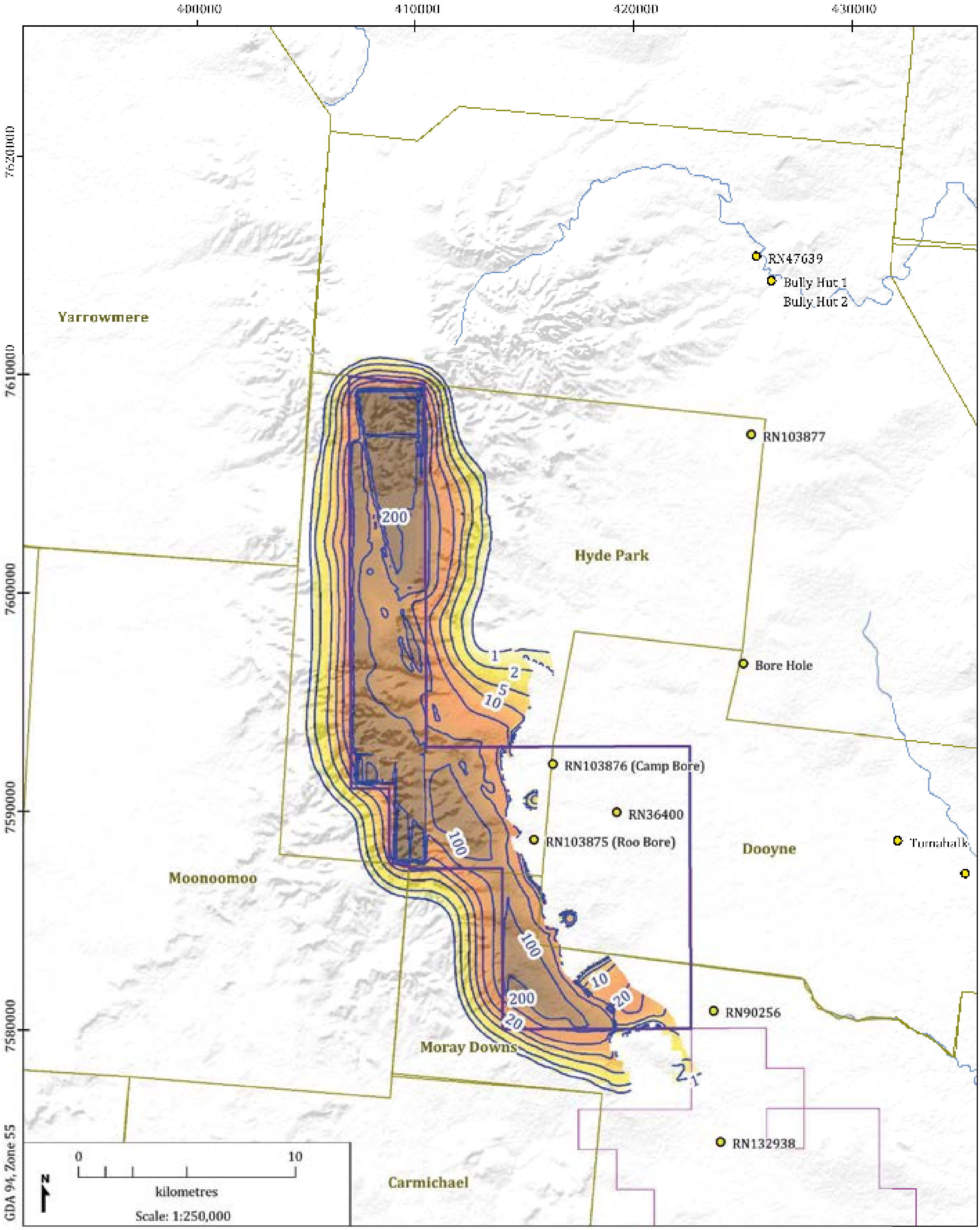
LEGEND:
- Maximum Drawdown contour (m)
- ● Private bore
- Project site
- Carmichael Coal Mine Project
- Major drainage
- ☐ Cadastre

Project China Stone (G1587)

Maximum zone of depressurisation during mining - Rewan Formation

DATE: 24/6/2015

FIGURE No: 30



LEGEND:

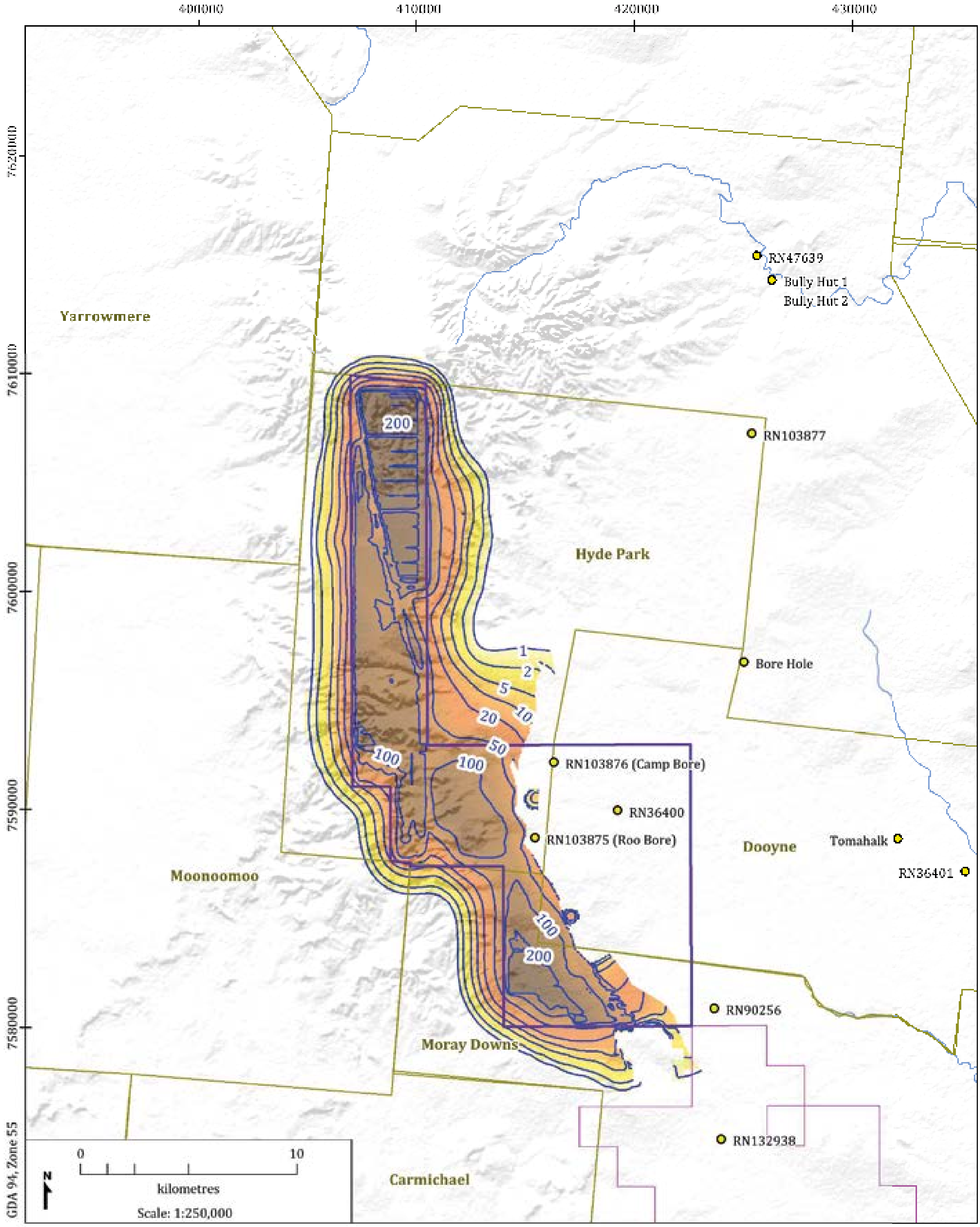
- Maximum Drawdown contour (m)
- Private bore
- Project site
- Carmichael Coal Mine Project
- Major drainage
- Cadastre

Project China Stone (G1587)

Maximum zone of depressurisation during mining - A seam and Betts Creek Beds

DATE: 24/6/2015

FIGURE No: **31**



LEGEND:

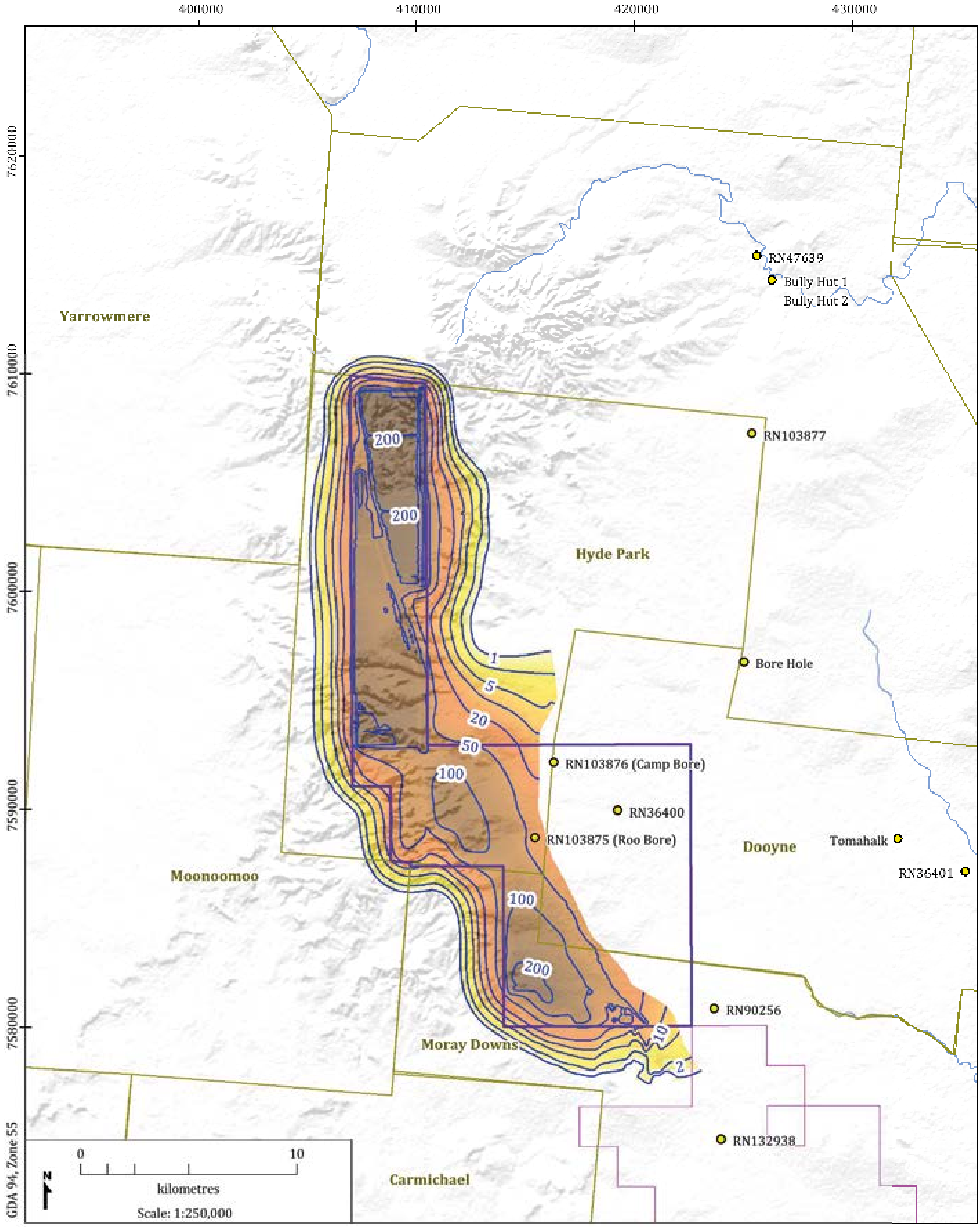
- Maximum Drawdown contour (m)
- Private bore
- Project site
- Carmichael Coal Mine Project
- Major drainage
- Cadastre

Project China Stone (G1587)

Maximum zone of depressurisation during mining - C seam/Betts Creek Beds

DATE: 24/6/2015

FIGURE No: 32



LEGEND:

Maximum Drawdown contour (m)

● Private bore

Project site

Carmichael Coal Mine Project

Major drainage

☐ Cadastre

Project China Stone (G1587)

Maximum zone of depressurisation during mining - D seam/Betts Creek Beds

DATE: 24/6/2015

FIGURE No: 33

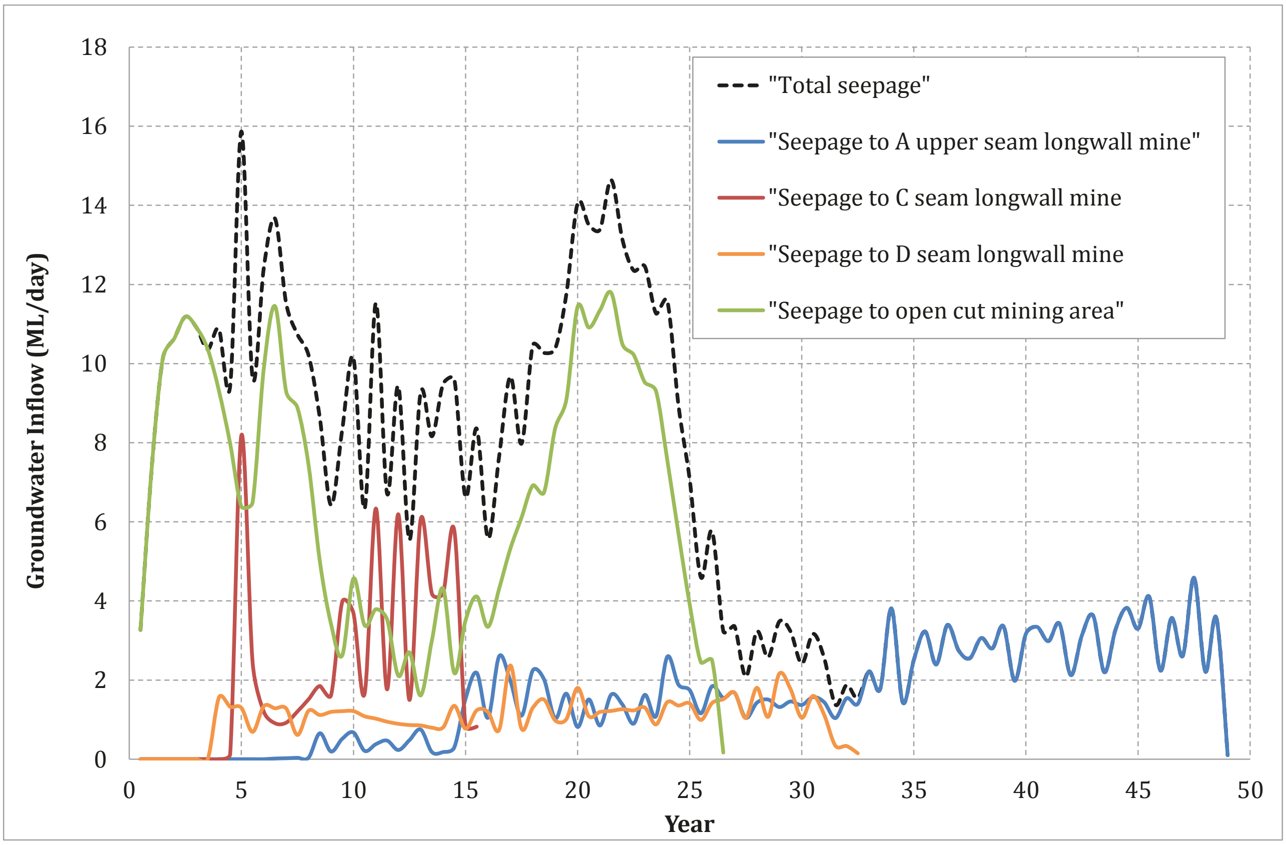
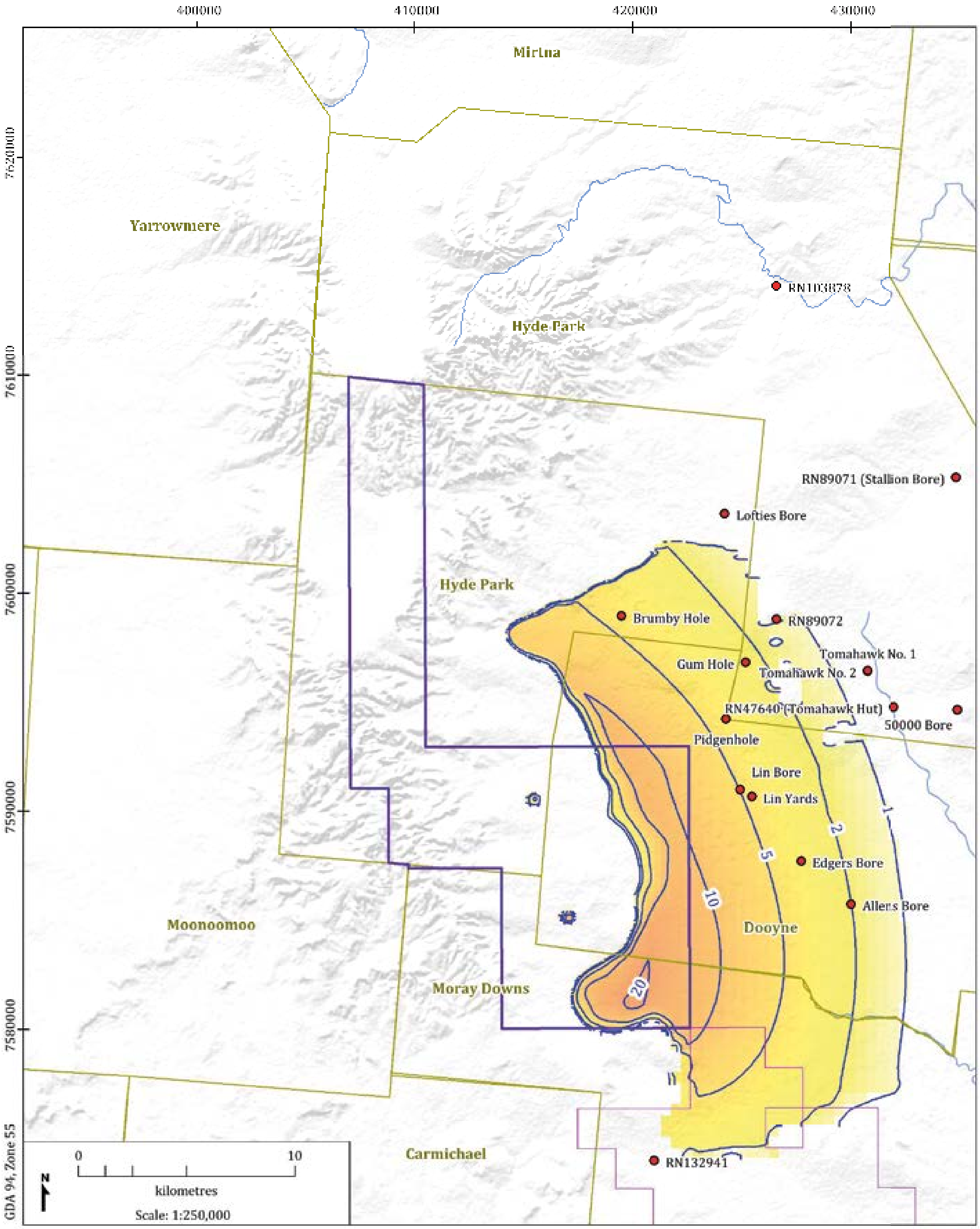


Figure 34 **Simulated seepage into proposed mining areas**



LEGEND:

Drawdown contour (m)

● Private bore

Project site

Carmichael Coal Mine Project

Major drainage

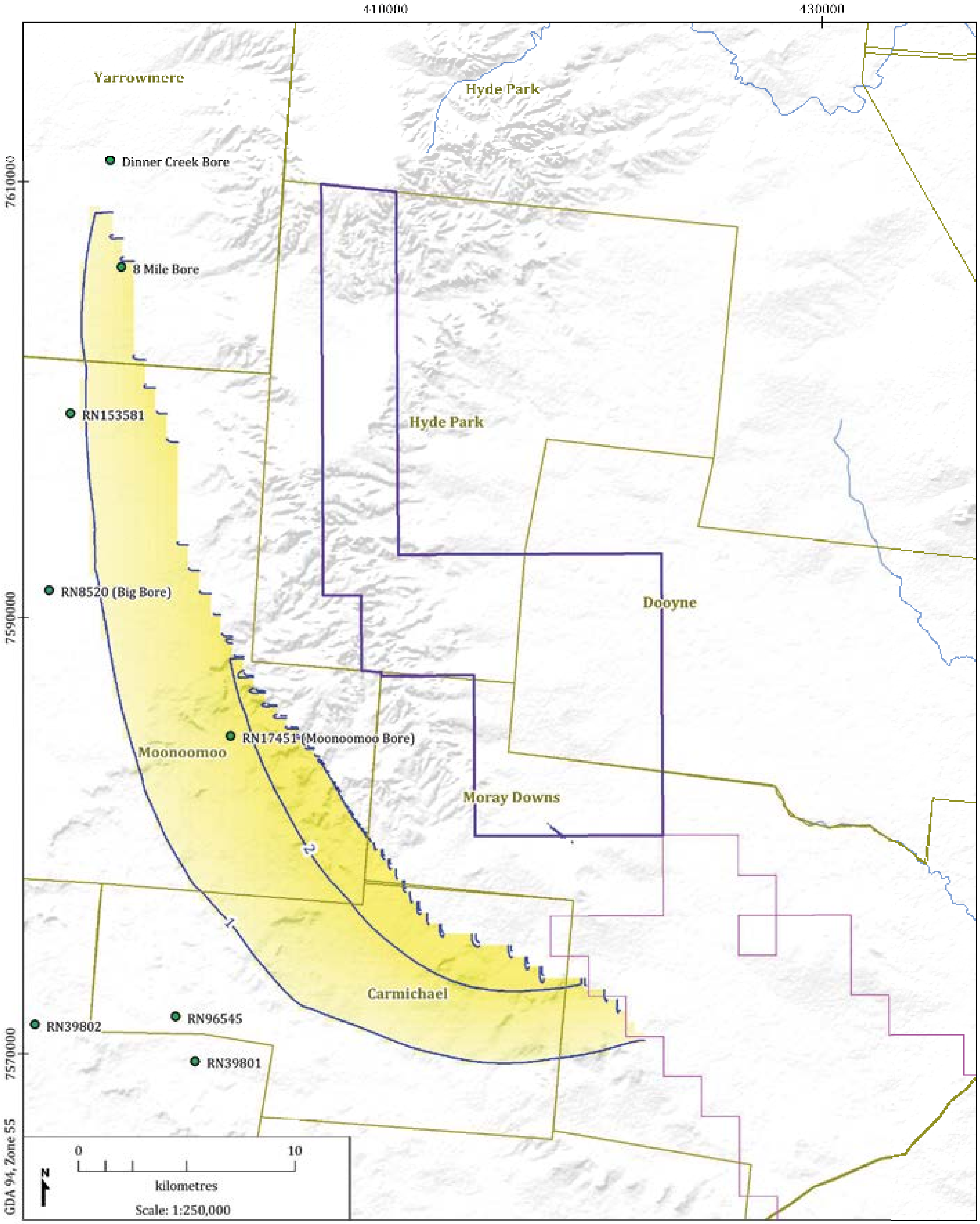
☐ Cadastre

Project China Stone (G1587)

Zone of depressurisation - Tertiary Sediments - post mining

DATE: 24/6/2015

FIGURE No: 35

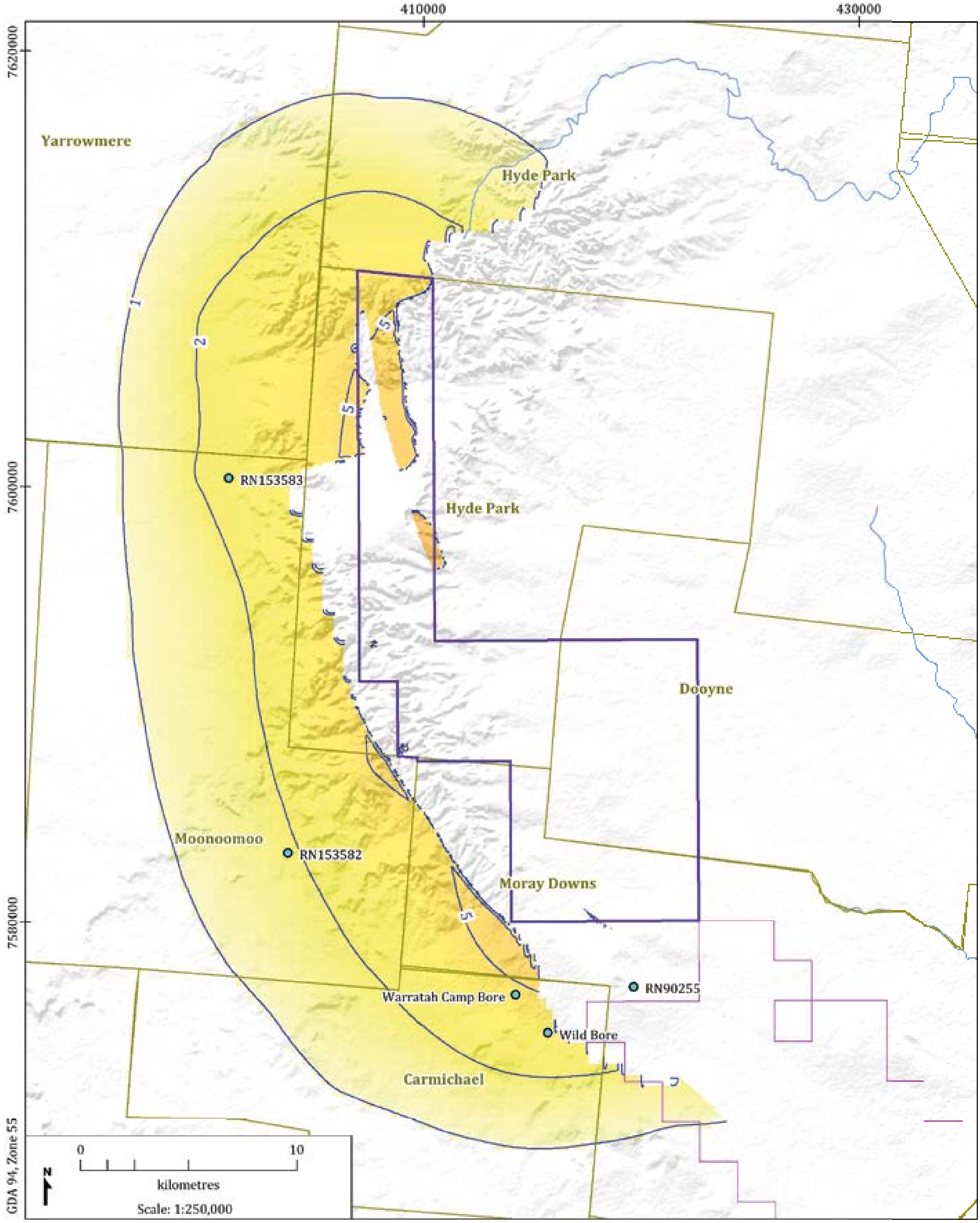


Project China Stone (G1587)

Zone of depressurisation - Moolayember Formation - post mining

DATE: 24/6/2015

FIGURE No: 36



LEGEND:

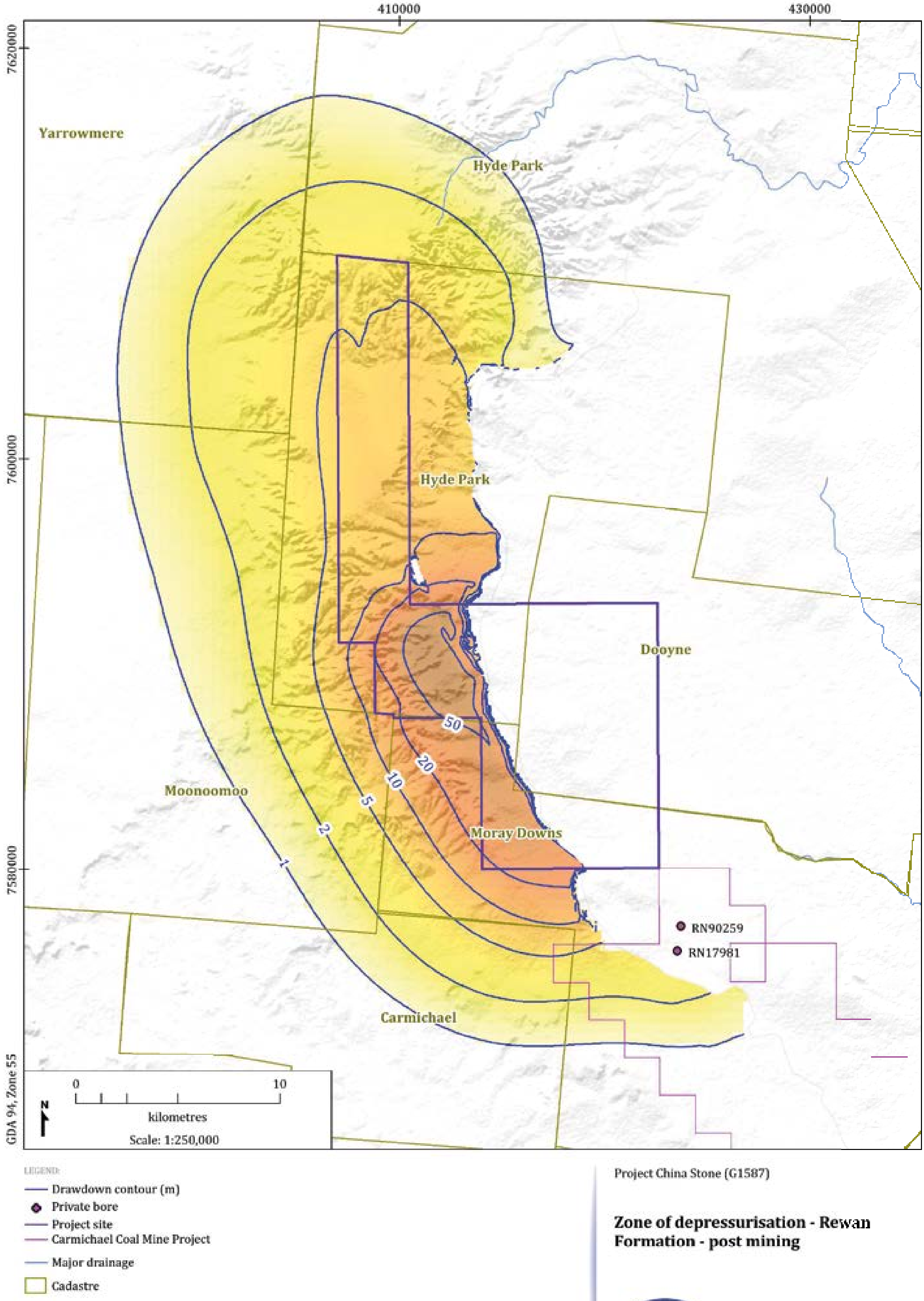
- Drawdown contour (m)
- Private bore
- Project site
- Carmichael Coal Mine Project
- Major drainage
- Cadastre

Project China Stone (G1587)

Zone of depressurisation - Clematis Sandstone - post mining

DATE: 24/6/2015

FIGURE No: 37

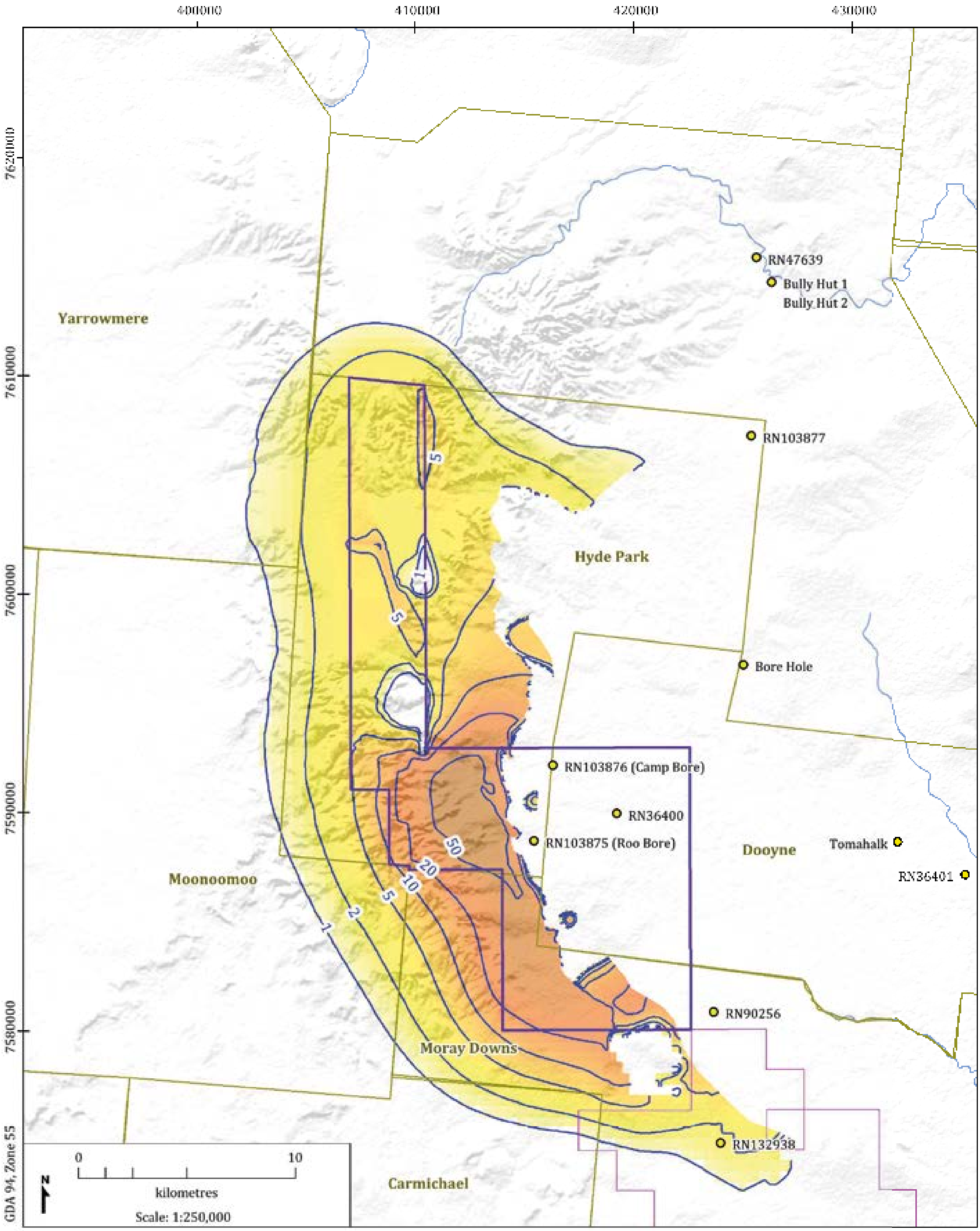


Project China Stone (G1587)

Zone of depressurisation - Rewan Formation - post mining

DATE: 24/6/2015

FIGURE No: 38



LEGEND:

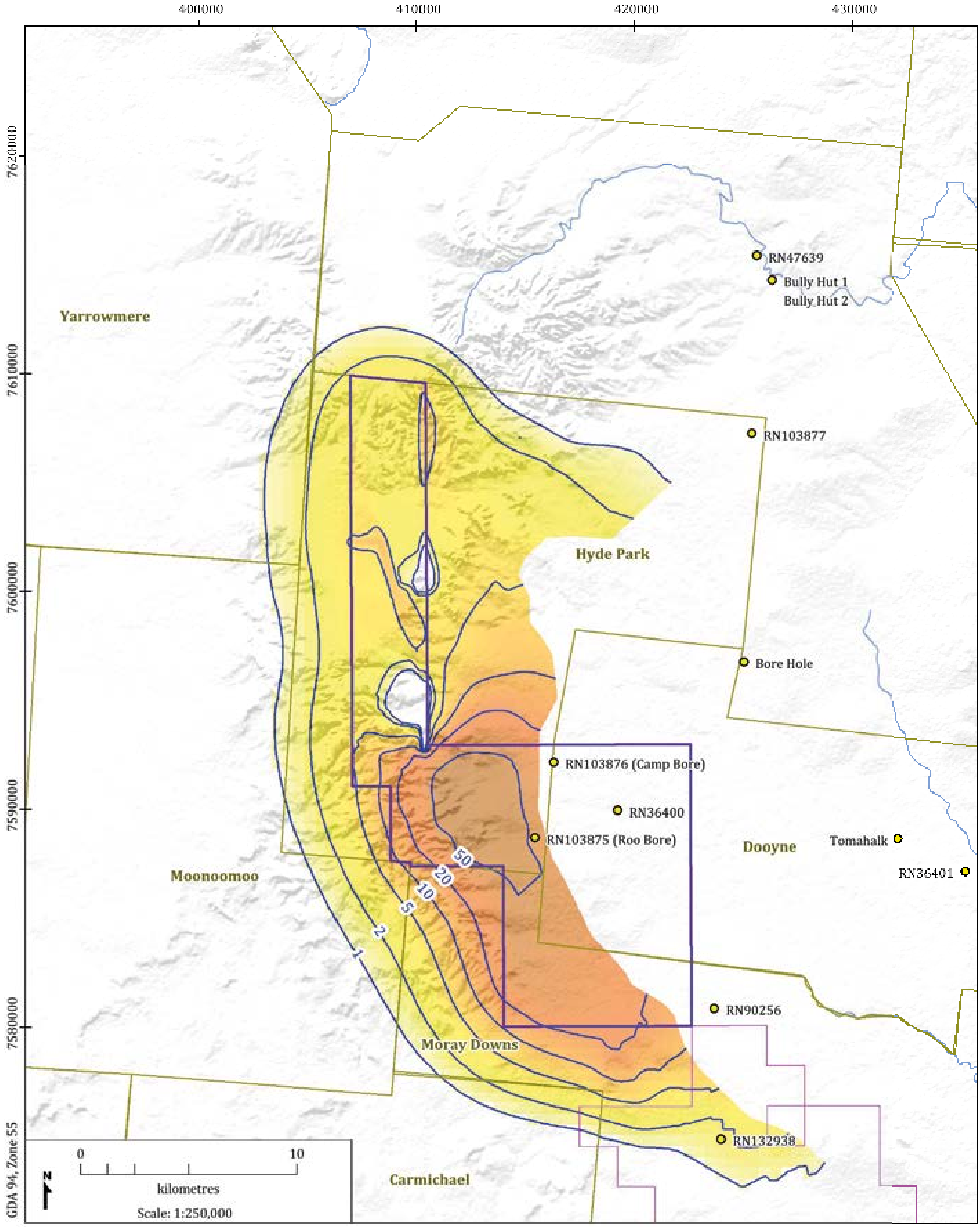
- Drawdown contour (m)
- ● Private bore
- Project site
- Carmichael Coal Mine Project
- Major drainage
- ☐ Cadastre

Project China Stone (G1587)

Zone of depressurisation - A seam post mining

DATE: 24/6/2015

FIGURE No: 39

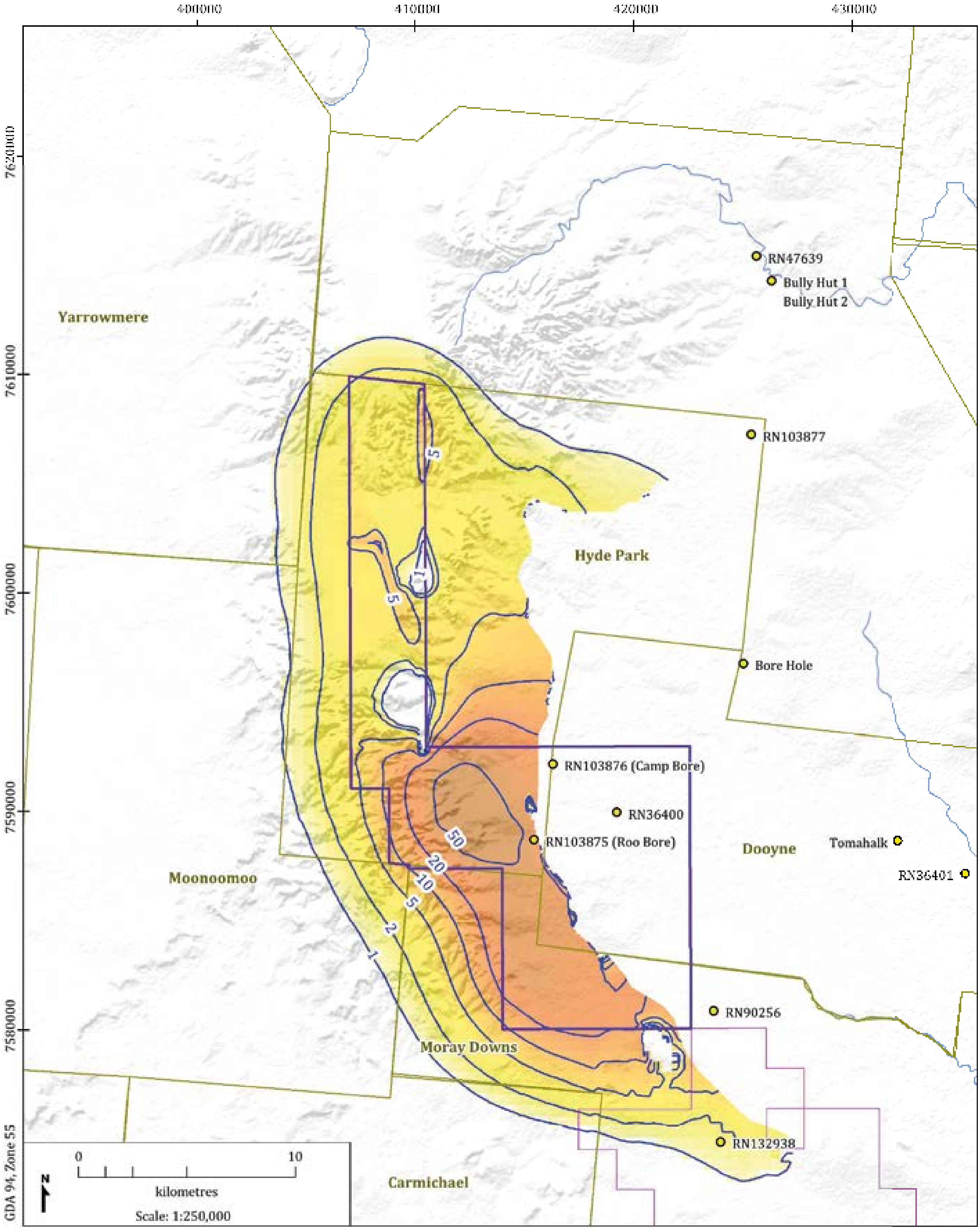


Project China Stone (G1587)

Zone of depressurisation - C seam post mining

DATE: 24/6/2015

FIGURE No: **40**



LEGEND:

- Drawdown contour (m)
- Private bore
- Project site
- Carmichael Coal Mine Project
- Major drainage
- Cadastre

Project China Stone (G1587)

Zone of depressurisation - D seam post mining

DATE: 24/6/2015

FIGURE No: 41

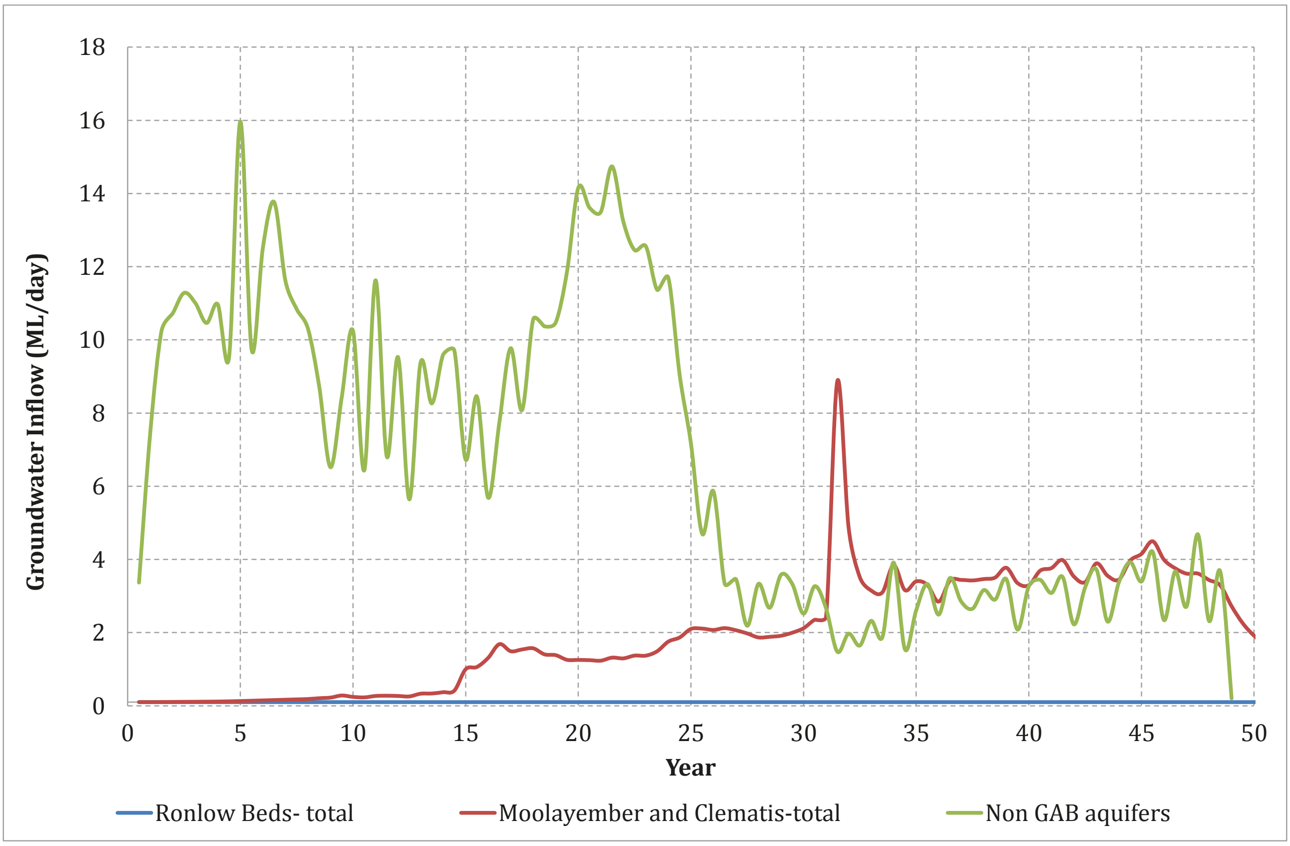
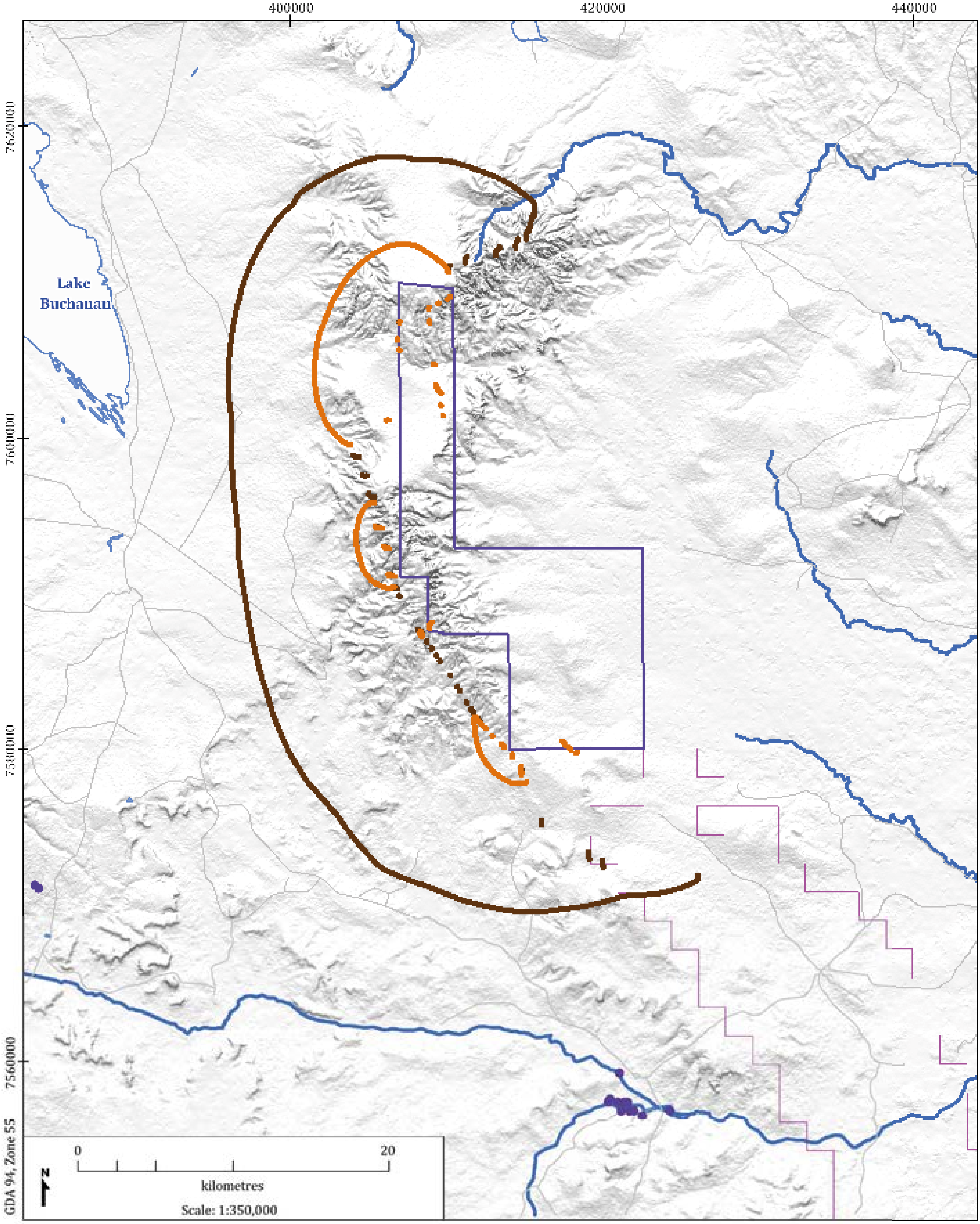


Figure 42 ‘Water take’ – during mining



LEGEND:

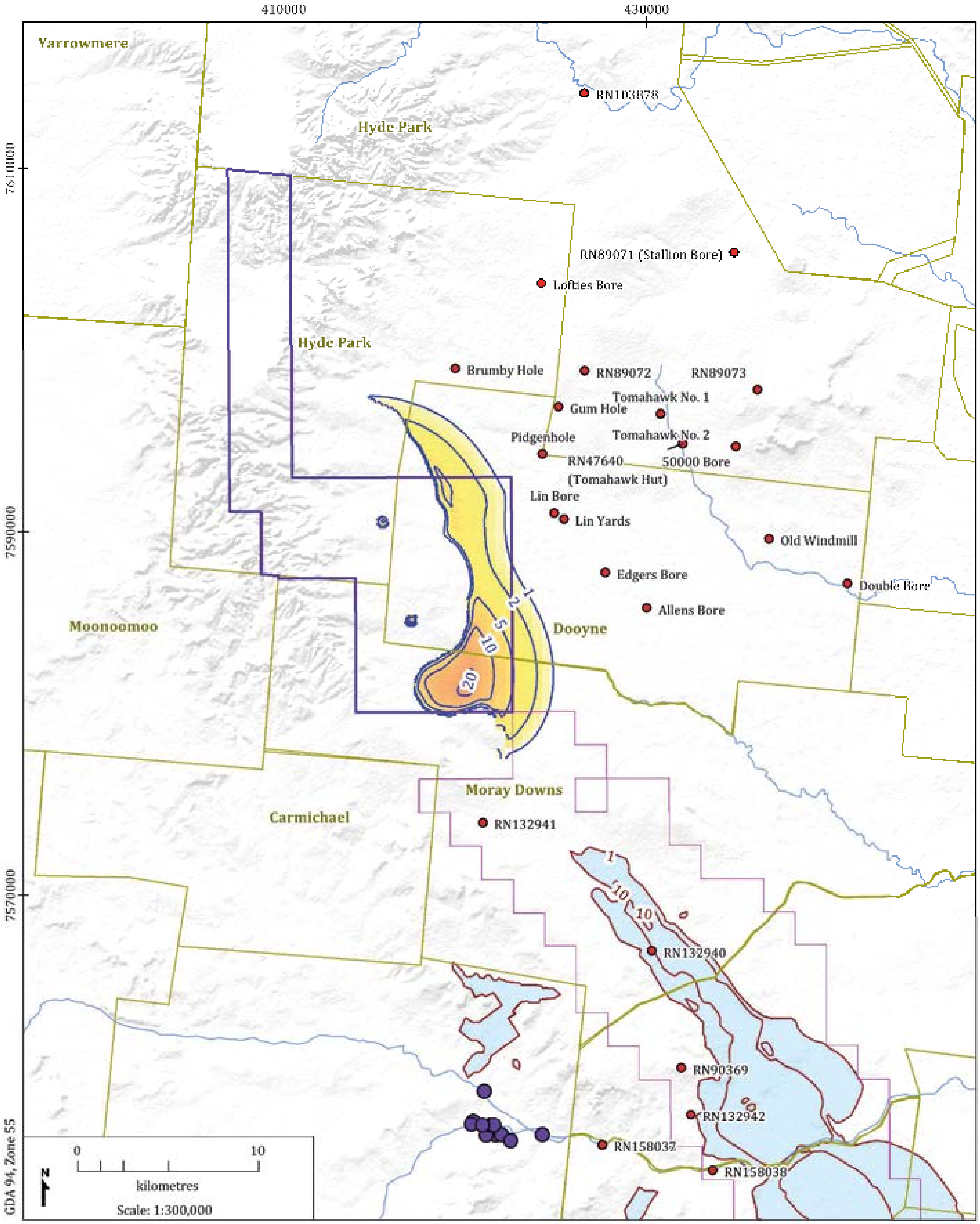
— Project site
— Carmichael Coal Mine Project
● GAB Springs
— Major features
— Road
— Maximum drawdown during mining - 1m contour
— Drawdown post mining - 1m contour

Project China Stone (G1587)

Groundwater interaction with surface water

DATE: 24/6/2015

FIGURE No: 43



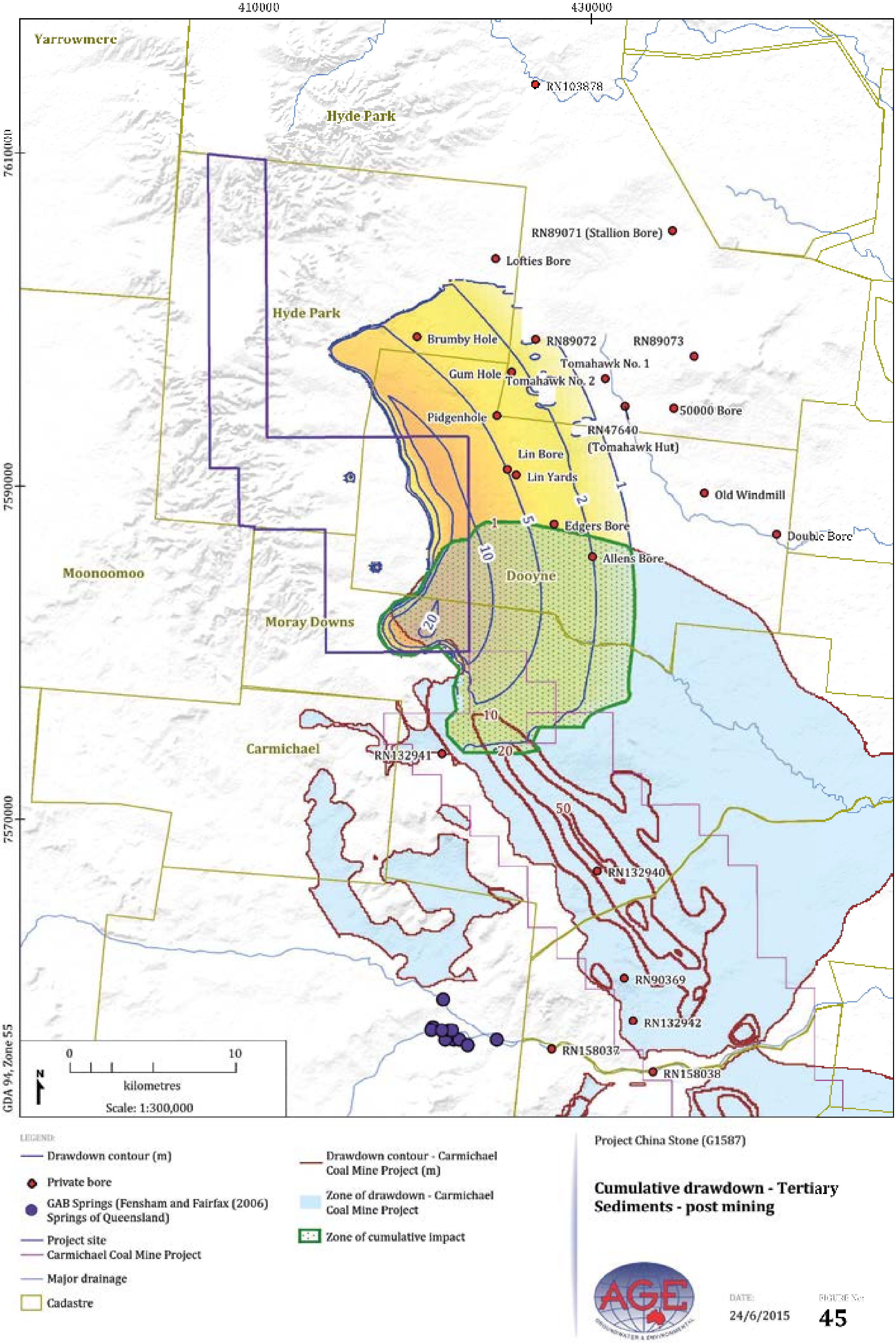
LEGEND:

- Drawdown contour (m)
- ● Private bore
- ● GAB Springs (Fensham and Fairfax (2006) Springs of Queensland)
- Project site
- Carmichael Coal Mine Project
- Major drainage
- ☐ Cadastre
- Drawdown contour - Carmichael Coal Mine Project (m)
- ▨ Zone of drawdown - Carmichael Coal Mine Project

Project China Stone (G1587)

Cumulative drawdown - Tertiary Sediments - end of mining

DATE:	FIGURE No:
24/6/2015	44

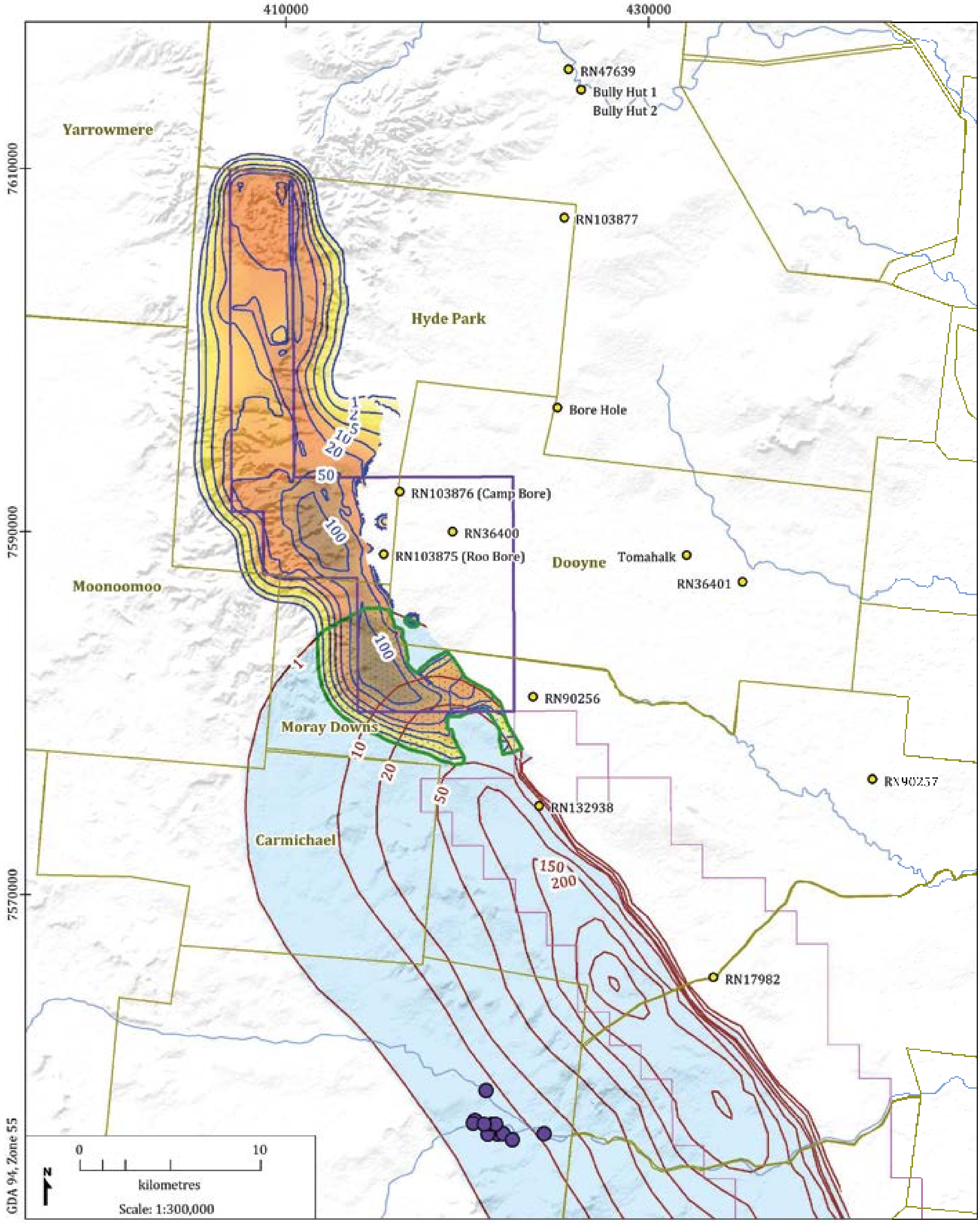


Project China Stone (G1587)

Cumulative drawdown - Tertiary Sediments - post mining

DATE: 24/6/2015

FIGURE No: 45



LEGEND:

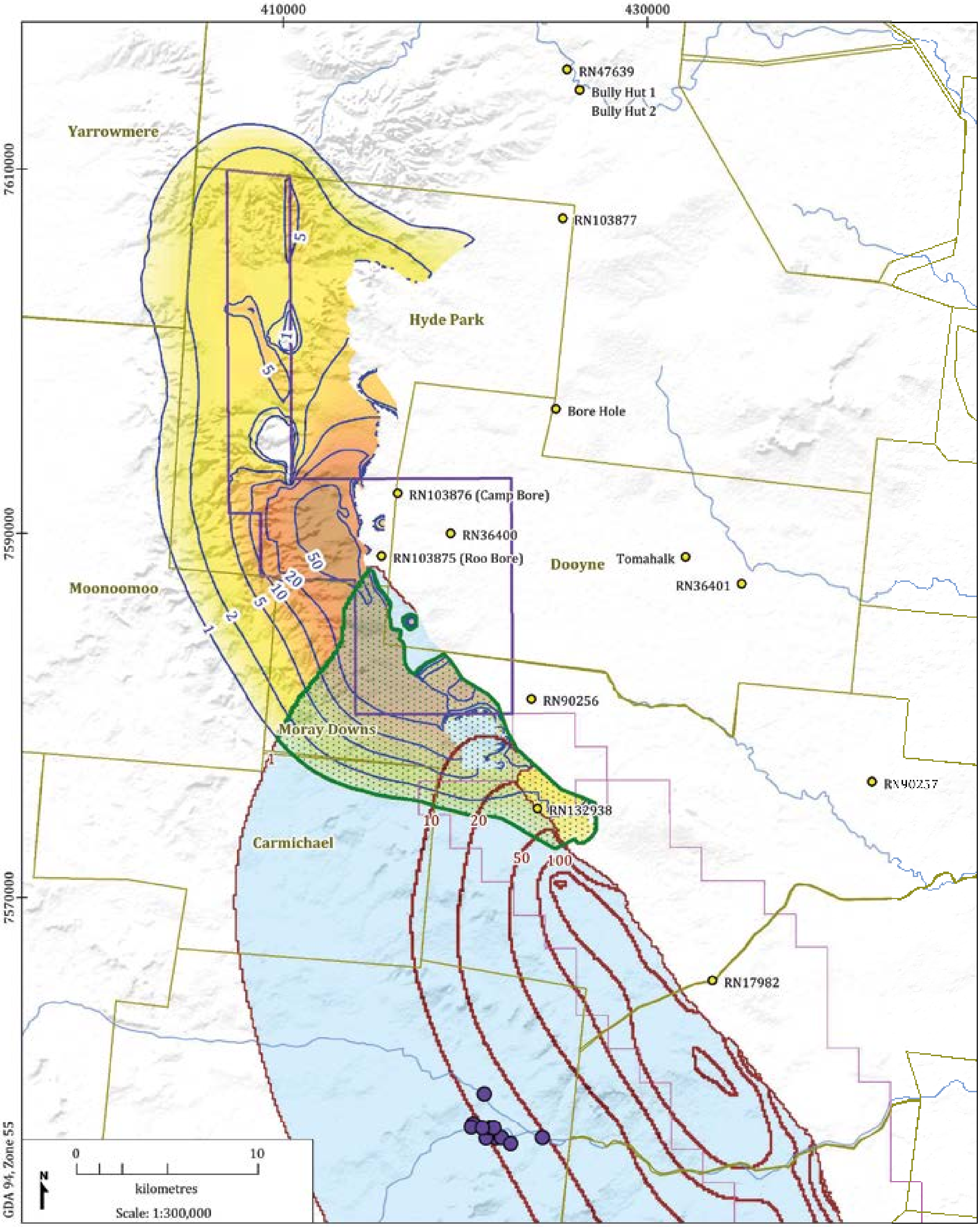
- Drawdown contour (m)
- ● Private bore
- ● GAB Springs (Fensham and Fairfax (2006) Springs of Queensland)
- Project site
- Carmichael Coal Mine Project
- Major drainage
- ☐ Cadastre
- Drawdown contour - Carmichael Coal Mine Project (m)
- Zone of drawdown - Carmichael Coal Mine Project
- Zone of cumulative impact

Project China Stone (G1587)

Cumulative drawdown – Coal seams (A China Stone - A/B Carmichael) - end of mining

DATE: 24/6/2015

FIGURE No: 46



LEGEND:

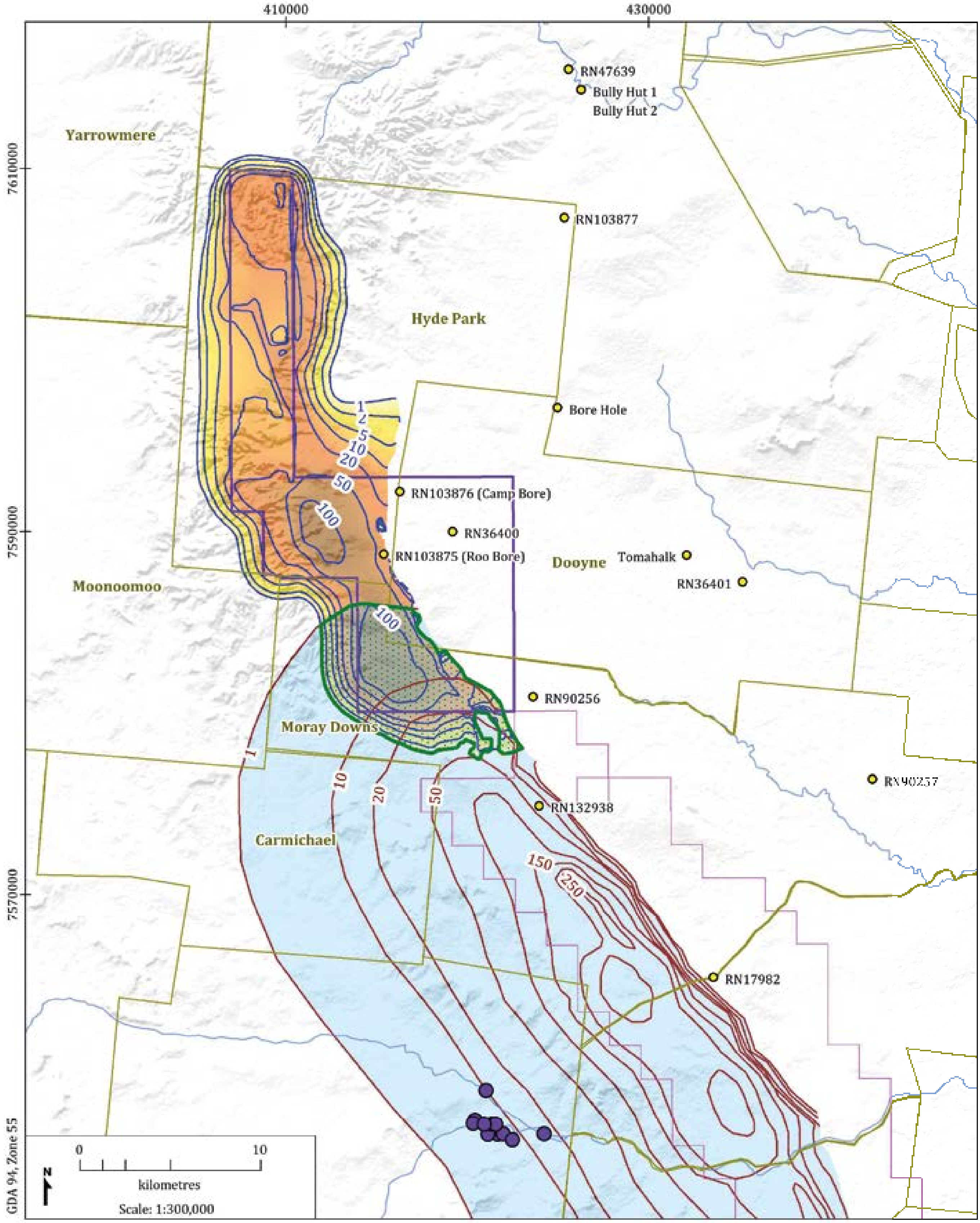
- Drawdown contour (m)
- ● Private bore
- ● GAB Springs (Fensham and Fairfax (2006) Springs of Queensland)
- Project site
- Carmichael Coal Mine Project
- Major drainage
- ☐ Cadastre
- Drawdown contour - Carmichael Coal Mine Project (m)
- 🟦 Zone of drawdown - Carmichael Coal Mine Project
- ▨ Zone of cumulative impact

Project China Stone (G1587)

Cumulative drawdown – Coal seams (A China Stone - A/B Carmichael) - post mining

DATE: 24/6/2015

FIGURE No: **47**



LEGEND:

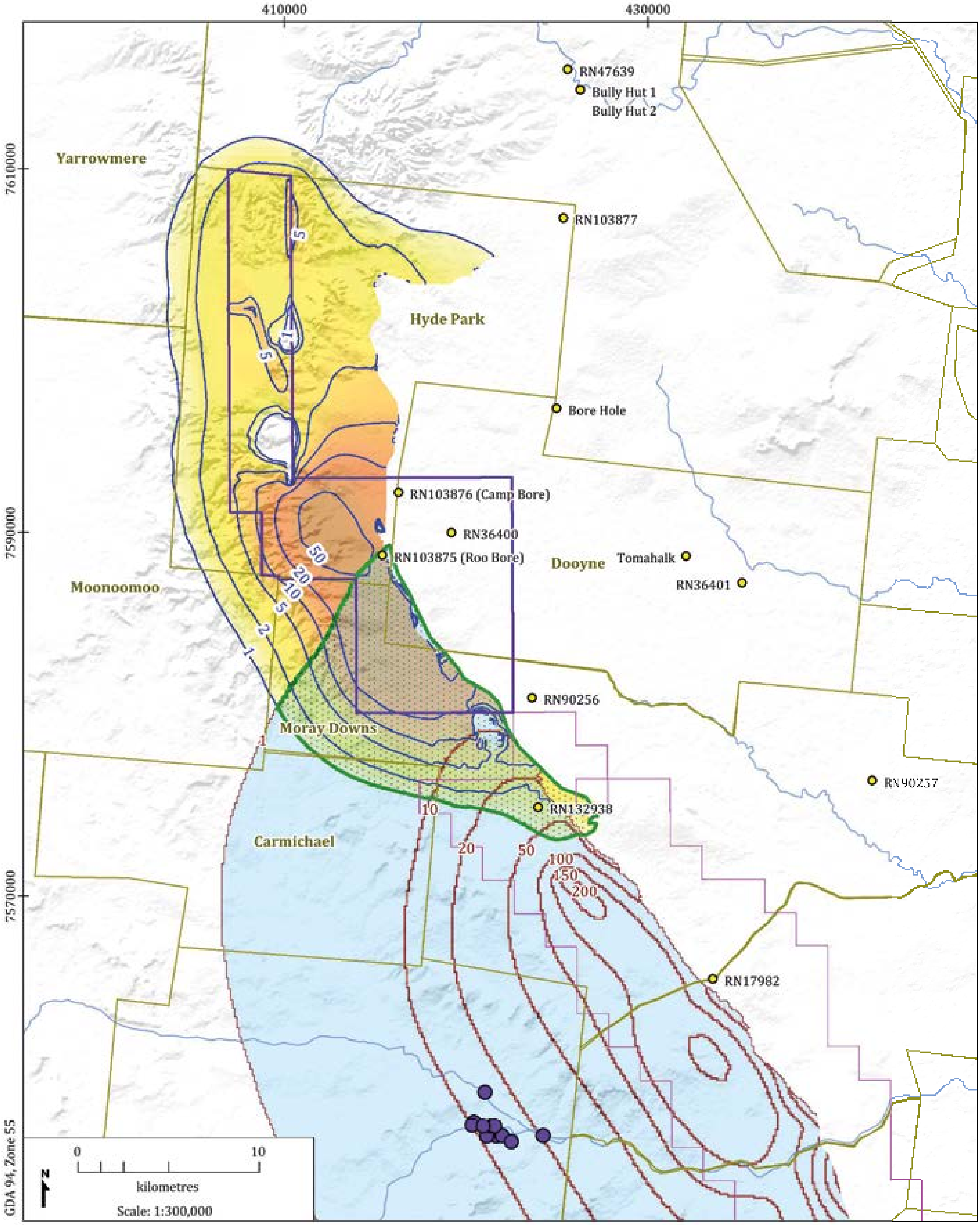
- Drawdown contour (m)
- ● Private bore
- ● GAB Springs (Fensham and Fairfax (2006) Springs of Queensland)
- Project site
- Carmichael Coal Mine Project
- Major drainage
- ☐ Cadastre
- Drawdown contour - Carmichael Coal Mine Project (m)
- ▨ Zone of drawdown - Carmichael Coal Mine Project
- ▨ Zone of cumulative impact

Project China Stone (G1587)

Cumulative drawdown - Coal seams (D seam) - end of mining

DATE: 24/6/2015

FIGURE No: 48



LEGEND:

- Drawdown contour (m)
- Private bore
- GAB Springs (Fensham and Fairfax (2006) Springs of Queensland)
- Project site
- Carmichael Coal Mine Project
- Major drainage
- Cadastre
- Drawdown contour - Carmichael Coal Mine Project (m)
- Zone of drawdown - Carmichael Coal Mine Project
- Zone of cumulative impact

Project China Stone (G1587)

Cumulative drawdown - Coal seams (D seam) - post mining

DATE: 24/6/2015

FIGURE No: 49

Appendix A

Field investigation report

A1. Field investigations

Field investigations into the hydrogeology of the project site were undertaken between December 2012 and August 2013 and included:

- Drilling and constructing a groundwater monitoring network;
- Post-drilling field measurements of groundwater distribution, water quality, hydraulic properties including falling head and packer testing; and
- A bore census to confirm the extent of existing groundwater use and surface expression of groundwater.

A2. Groundwater drilling

Groundwater drilling comprised:

- drilling and construction of 31 groundwater monitoring bores;
- drilling and construction of 4 vibrating wire piezometer (VWP) arrays; and
- drilling 8 HQ core hole for the purpose of packer testing.

The drilling layout and construction details are discussed in the following sections.

A2.1 Groundwater monitoring bores

A total of 31 groundwater monitoring bores were drilled and constructed between December 2012 and August 2013 and installed by a licenced water bore driller.

Appendix A-1 provides a summary of the construction details for each groundwater monitoring bore drilled at the project site. Appendix A-2 provides composite logs outlining the stratigraphy and lithology, bore construction, and drilling details for each groundwater monitoring bore. All bores were logged by a Macmines geologist; an AGE hydrogeologist provided guidance on the bore design.

The groundwater monitoring bores were located to allow monitoring of major geological units at the project site and provide a robust coverage of the project area. Six sites consist of multiple bores screened at different depths to measure the vertical gradient between formations, these include:

- MB04, MB05, and MB06;
- MB07, and MB08;
- MB09, MB10, and MB11;
- MB16, and MB17;
- MB18, and MB19; and
- MB20, and MB32.

Monitoring bores were drilled using open-hole rotary drilling techniques. The monitoring bores were supervised by a hydrogeologist or geologist and constructed with 50 mm diameter, flush threaded, Class 18 uPVC with Class 18 machine slotted (0.4 mm aperture) uPVC screen. The screen aperture was opened to a 1 mm slot for every metre of screen to align with stygofauna monitoring requirements. Stygofauna monitoring is discussed in the EIS aquatic ecology report.

A filter pack of clean rounded to sub-rounded gravel of 3 mm to 6 mm diameter was placed in the annulus above the screen. A layer of bentonite pellets (1 m to 2 m) was placed above the filter pack to form a seal to hydraulically isolate the screened section. A cement/bentonite grout was used to seal the remaining bore annulus. A steel lockable protector was cemented around the protruding casing at the surface.

All holes were drilled and constructed according to the guidelines presented in the '*Minimum Construction Requirements for Water Bores in Australia*'[1]. The following sections document the drilling and construction of the monitoring bores.

A2.2 Bore development

Bores were airlift developed to remove drilling fines and enhance hydraulic conductivity within the surrounding aquifer. Developing continued until all fines were removed and field water quality parameters (for pH and electrical conductivity) had stabilised.

Where monitoring bores did not yield sufficient flow to enable adequate development a powered bailer (similar to a small cable tool drilling rig) was used to remove fluid in the bore until the pH stabilised.

A2.3 Groundwater levels and logger installations

Groundwater levels were measured manually using a water level dipper for all monitoring bores throughout the field investigation. Groundwater level data is discussed in detail in Section 6.1 of the main report.

Solinst leveloggers were installed in all monitoring bores and set to record at 6-hourly intervals. A barometric logger was placed inside the protective collar of MB06 and set to record concurrently with the other data loggers.

A2.4 Survey bore locations

On completion of the drilling program all bores were surveyed by a licensed surveyor to accurately measure their position and height. Appendix A-1 presents the surveyed bore coordinates and elevations for each bore. Figure 15 in the main body of the report shows the location of each bore. Table A 1 summarises the construction of each bore.

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[1] National Uniform Drillers Licensing Committee (2013) "*Minimum Construction Requirements for Water Bores in Australia*" Ed.3 Revised February 2013.

Table A 1 Groundwater monitoring bores – construction details

Hole ID	Age	Geological unit	Screened lithology	Elevation (mAHD)		Base of hole (mAHD)	Total drilled depth (mbGL)	Screen (mAHD)	Gravel pack (mAHD)	Mean static water level (mAHD)
				ToC	Ground					
MB07	Tertiary	Tertiary Sediments	clay	343.47	343.01	283	60	289 - 283	299 - 283	286.6
MB17	Tertiary	Tertiary Sediments	sand	329.54	329.04	252.4	76.65	258.3 - 252.3	262.3 - 252.3	266.3
MB18	Tertiary	Tertiary Sediments	sand	341.91	341.54	288.9	52.6	294.9 - 288.9	298.9 - 288.9	dry
MB20	Tertiary	Tertiary Sediments	sand	297.84^A	297.34	272.3	25	275.3 - 272.3	277.3 - 272.3	dry
MB32	Tertiary	Tertiary Sediments	sand	302.56^A	302.06	277.1	25	280.1 - 277.1	283.1 - 277.1	dry
MB04	Tertiary	Tertiary Sediments	silt and gravel	366.95	366.25	340.8	25.5	346.8 - 340.8	350.8 - 340.8	dry
MB16	Tertiary	Tertiary Sediments	silt and sand	329.63	329.03	304	25	307 - 304	309 - 304	dry
MB09	Tertiary and Permian	Tertiary Sediments and Betts Creek Beds	sand, silt and weathered sandstone	342.86	342.21	318.9	23.35	324.9 - 318.7	325.4 - 318.9	dry
MB31	Triassic	Clematis Sandstone	unknown	unknown	468.55	319.2	149.4	unknown	unknown	dry
MB21	Triassic	Clematis Sandstone	weathered sandstone	470.9^A	470.4	339.9	130.5	345.9 - 339.9	349.9 - 339.9	dry
MB29	Triassic	Clematis Sandstone	weathered sandstone	496.62^A	496.12	347.1	149	354.1 - 348.1	359.1 - 347.1	dry
MB30	Triassic	Clematis Sandstone	weathered sandstone	484.11^A	483.61	334.3	149.3	340.3 - 334.3	346.3 - 334.3	dry
MB22	Triassic	Clematis Sandstone	weathered sandstone	388.45^A	387.95	280.5	107.5	286.5 - 280.5	298.5 - 280.5	dry
MB23	Triassic	Rewan Formation	unknown	unknown	415.67	325.7	90	unknown	unknown	dry
MB24	Triassic	Rewan Formation	claystone	440.75	440	309	131	316 - 310	321.5 - 310	352.7
MB25	Triassic	Rewan Formation	claystone and siltstone	462.8	462	336.6	125.4	324.5 - 318.5	328.5 - 318.5	dry
MB12	Triassic	Rewan Formation	sandstone	377.57	376.92	275.9	101	280.9 - 274.9	286.9 - 274.9	314.7

Hole ID	Age	Geological unit	Screened lithology	Elevation (mAHD)		Base of hole (mAHD)	Total drilled depth (mbGL)	Screen (mAHD)	Gravel pack (mAHD)	Mean static water level (mAHD)
				ToC	Ground					
MB13	Triassic	Rewan Formation	sandstone	389.66	389.09	287.1	102	293.5 - 287.5	295.1 - 287.1	322.3
MB14	Triassic	Rewan Formation	sandstone	447.07	446.34	296.3	150	306.3 - 300.3	308.3 - 300.3	313.5
MB26	Triassic	Rewan Formation	sandstone	411.26	410.56	291	119.6	297.6 - 291.6	303.6 - 291.1	314.8
MB27	Triassic	Rewan Formation	sandstone and claystone	415.74	415.24	301.6	113.6	309.2 - 302.2	313.6 - 301.6	316.1
MB28	Triassic	Rewan Formation	sandstone and claystone	437a	436.5	298.5	138	304.5 - 298.5	310.5 - 298.5	319.5
MB19	Triassic	Rewan Formation	siltstone and claystone	341.96	341.51	258	83.5	267 - 261	273 - 258	289.8
MB15	Triassic	Rewan Formation	siltstone and sandstone	409.35	408.7	289.3	119.4	299.3 - 293.3	305.3 - 289.3	323.8
MB33	Triassic	Rewan Formation	weathered claystone	418.46	417.8	268.4	149.4	273.8 - 267.8	279.8 - 267.8	320.8
MB06	Permian	Betts Creek Beds	coal - A & B seams	366.42	366.02	226.5	139.5	241 - 232	261 - 229	294.8
MB11	Permian	Betts Creek Beds	coal - A & B seams	342.59	341.91	257.9	84	264.9 - 258.9	274.9 - 257.9	308.1
MB03	Permian	Betts Creek Beds	coal - A Seam	347.2	346.67	254.9	91.75	260.9 - 254.9	264.9 - 254.9	287.3
MB05	Permian	Betts Creek Beds	sandstone	366.79	366.14	258.1	108	264.1 - 258.1	274.1 - 258.1	294.7
MB08	Permian	Betts Creek Beds	weathered sandstone and siltstone	343.42[A]	342.92	252.9	90	260.8 - 254.8	270.8 - 254.8	282.9
MB10	Permian	Betts Creek Beds	weathered claystone	342.74	342.12	284.8	57.35	290.8 - 284.8	291.8 - 284.8	308.3

Notes:

Co-ordinates GDA94, Zone 55

mAHD = metres above height datum

mbGL = metres below ground level

[A] ToC elevation an estimate, data not supplied by

A2.5 Vibrating wire piezometers

A total of four VWP arrays were constructed during March and June 2013. The bores were drilled using the same drilling techniques used for the groundwater monitoring program. The installation of all VWPs was supervised by an AGE hydrogeologist.

Each VWP site was nested with an open standpipe monitoring bore which screened the Rewan overburden. These, along with the three sensors in each VWP array, provide the ability to assess any vertical differences in groundwater pressures between geological units.

Table A 2 shows the depths and target geological units for each VWP sensor.

Table A 2 Vibrating wire piezometers – construction details

Hole ID	Nested monitoring bore	Ground level (mAHD)	Base of hole (mAHD)	Total drilled depth (mbGL)	Age	Geological unit	Sensor lithology	Depth of gauge (mAHD)	Groundwater pressure head (mAHD)
VWP1	MB12	385	34.2	350.8	Triassic	Rewan Formation	siltstone	195	318.82
					Permian	Betts Creek Beds	sandstone	165	315.68
					Permian	Betts Creek Beds	coal - A Seam	140	312.4
VWP2	MB13	398	91.5	306.5	Permian	Betts Creek Beds	sandstone	213	304.75
					Permian	Betts Creek Beds	coal - A Seam	188	299.79
					Permian	Betts Creek Beds	sandstone	148	297.71
VWP3	MB14	458	109.7	348.3	Triassic	Rewan Formation	siltstone	268	304.58
					Permian	Betts Creek Beds	sandstone	238	295.86
					Permian	Betts Creek Beds	siltstone	218	295.93
VWP4	MB15	418	168	250	Triassic	Rewan Formation	siltstone	258	347.84
					Triassic	Rewan Formation	sandstone	218	327.8
					Triassic	Rewan Formation	siltstone	178	298.98

Notes: *mAHD = metres above height datum*

A3. In-situ permeability testing

A3.1 Falling head tests

As a part of the investigation, 18 falling head tests were completed on 16 bores. The testing was designed to evaluate the hydraulic conductivity of aquifer material surrounding the bore screen. Falling head tests involve rapidly displacing the head of water in the bore and measuring the rate of recovery; from this the hydraulic conductivity of the aquifer is calculated.

The bores were analysed using either the Cooper-Bredehoeft-Papadopulos (1967)[2] method for leaky confined aquifers or the Hvorslev (1953)[3] method for confined aquifers.

Tests were completed by either NRC in March 2013 or an AGE Hydrogeologist in June and July 2013. Table A 3 shows the details for each test. Section 6.1 in the main report summarises all hydraulic test data for the different groundwater units.

Table A 3 Falling head test details

Bore No.	Geological unit	Age	Unit	Lithology	Method	Hydraulic conductivity (m/day)	Test completed by
MB03	Coal - A Seam	Permian	Betts Creek Beds	Coal - A Seam	Hvorslev	0.04	AGE
MB05	Betts Creek Beds (Permian overburden)	Permian	Betts Creek Beds	sandstone	Hvorslev	0.0001	NRC
MB06	Coal - A & B Seams	Permian	Coal - A & B Seams	Coal - A & B seams	Hvorslev	0.04	AGE
MB07	Tertiary sediments	Tertiary	Tertiary sediments	clay	Hvorslev	0.01	AGE
MB07	Tertiary sediments	Tertiary	Tertiary sediments	clay	Hvorslev	0.04	NRC
MB08	Weathered Betts Creek Beds (Permian overburden)	Permian	Betts Creek Beds	claystone, siltstone, and sandstone	Hvorslev	0.9	AGE
MB08	Weathered Betts Creek Beds (Permian overburden)	Permian	Betts Creek Beds	claystone, siltstone, and sandstone	Hvorslev	0.02	NRC
MB10	Weathered Betts Creek Beds (Permian overburden)	Permian	Betts Creek Beds	claystone	Hvorslev	0.1	AGE
MB11	Coal - A & B Seams	Permian	Betts Creek Beds	Coal - A & B Seams	Hvorslev	0.2	AGE
MB12	Rewan Group (sandstone)	Triassic	Rewan Formation	sandstone	Hvorslev	0.002	AGE
MB13	Rewan Group (sandstone)	Triassic	Rewan Formation	sandstone	Hvorslev	0.2	AGE
MB17	Tertiary sediments	Tertiary	Tertiary sediments	sandstone	Hvorslev	0.6	AGE

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[2] Cooper, H.H., Bredehoeft, J.D., and Papadopulos, S.S., (1967) '*Response of a finite-diameter well to an instantaneous charge of water*', Water Resources Research, vol. 3, no. 1, pp. 263-269.

[3] Hvorslev, 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, pp. 1-50.

Bore No.	Geological unit	Age	Unit	Lithology	Method	Hydraulic conductivity (m/day)	Test completed by
MB19	Rewan Group (siltstone/claystone)	Triassic	Rewan Formation	siltstone and claystone	Hvorslev	0.08	AGE
MB22	Weathered Clematis Sandstone	Triassic	Clematis Sandstone	sandstone	Hvorslev	0.09	NRC
MB24	Rewan Group (claystone)	Triassic	Rewan Formation	claystone	Cooper-Bredehoeft-Papadopulos	0.02	NRC
MB27	Rewan Group (sandstone and claystone)	Triassic	Rewan Formation	sandstone and claystone	Cooper-Bredehoeft-Papadopulos	0.09	NRC
MB28	Rewan Group (sandstone and claystone)	Triassic	Rewan Formation	sandstone and claystone	Hvorslev	0.06	NRC
MB33	Weathered Rewan Group (upper claystone)	Triassic	Rewan Formation	claystone	Hvorslev	0.0005	AGE

A3.2 Packer tests

Packer tests consist of isolating a section of a bore hole with inflatable packers so aquifer tests can be conducted on a discrete zone or feature (e.g. a coal seam or fault). The Lugeon (1933)[4] method was used to estimate the hydraulic conductivity of the test interval. The Lugeon Test is similar to a constant head test where water is injected into the test interval at a constant pressure and the flow rate is measured. Generally the test is conducted over 5 stages at different pressures. During each stage the average pressure and flow rate are recorded, his data is used to calculate the hydraulic conductivity for each stage.

A total of 68 packer tests were carried out in the project site within eight drill holes between July and October 2013 using a Sigra inflatable straddle packer. Each test was supervised by either an AGE hydrogeologist or Macmines geologist. Table A 4 presents the packer test details for all tests. Appendix A-2 contains the bore logs for each packer test hole.

Table A 4 Packer test details

Hole ID	Test interval (mbGL)	Age	Unit	Lithology	Test No.	Interpreted hydraulic conductivity (m/day)
MC5040A	198.5 - 203.5	Triassic	Rewan Formation	siltstone and sandstone	4	0.001
	225.5 - 230.5	Permian	Betts Creek Beds	sandstone	3	0.007
	250 - 255	Permian	Betts Creek Beds	sandstone	2	0.002
	262 - 357.2	Triassic	Rewan and Betts Creek Beds	siltstone, sandstone, and coal	1	0.006
MC5041	72.9 - 77.9	Permian	Betts Creek Beds	siltstone	14	0.002
	78 - 83	Permian	Betts Creek Beds	siltstone and claystone	13	0.001
	89.8 - 94.8	Permian	Betts Creek Beds	coal - AU Seam	12	0.002

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[4] Lugeon, M., (1933) '*Barrage et Gèologie*', Dunod, Paris

Hole ID	Test interval (mbGL)	Age	Unit	Lithology	Test No.	Interpreted hydraulic conductivity (m/day)
	98.8 - 103.8	Permian	Betts Creek Beds	coal - AL Seam	11	0.002
	107.8 - 112.8	Permian	Betts Creek Beds	coal - B Seam	10	0.002
	117 - 122	Permian	Betts Creek Beds	siltstone	9	0.003
	123.7 - 128.7	Permian	Betts Creek Beds	coal - C4 / C3 Seam	8	0.015
	131.5 - 134.5	Permian	Betts Creek Beds	coal - C2 Seam	7	0.005
	137.8 - 142.8	Permian	Betts Creek Beds	sandstone	6	0.002
	145.5 - 149.5	Permian	Betts Creek Beds	siltstone	5	0.002
	150.5 - 155.5	Permian	Betts Creek Beds	coal - D Seam	4	0.003
	159.5 - 164.5	Permian	Betts Creek Beds	coal - E Seam	3	0.013
	165.6 - 169.6	Permian	Betts Creek Beds	coal - F Seam	2	0.01
	172 - 176	Permian	Betts Creek Beds	coarse sandstone	1	0.004
MC5043	148 - 153	Triassic	Rewan Formation	siltstone	10	0.002
	202 - 207	Permian	Betts Creek Beds	sandstone and siltstone	9	0.002
	247 - 252	Permian	Betts Creek Beds	coal - Au2/Au1 Seam	8	0.002
	271 - 276	Permian	Betts Creek Beds	coal - B2/B1 Seam	7	0.002
	279 - 283	Permian	Betts Creek Beds	coal - C5 Seam	6	0.002
	291 - 295	Permian	Betts Creek Beds	sandstone and siltstone	5	0.002
	294.8 - 299.8	Permian	Betts Creek Beds	coal - D Seam	4	0.021
	309 - 313	Permian	Betts Creek Beds	coal - E Seam	3	0.005
	318 - 322	Permian	Betts Creek Beds	coal - F Seam	2	0.003
	324 - 329	Permian	Betts Creek Beds	coarse sandstone	1	0.005
MC5044	148 - 153	Triassic	Rewan Formation	sandstone and siltstone	11	0.005
	175 - 180	Triassic	Rewan Formation	sandstone and siltstone	10	0.009
	259 - 264	Permian	Betts Creek Beds	carbonaceous siltstone	9	0.006
	274 - 278	Permian	Betts Creek Beds	coal - AU1 - Seam	8	0.005
	280 - 285	Permian	Betts Creek Beds	coal - AL- Seam	7	0.008
	292 - 297	Permian	Betts Creek Beds	coal - B-Seam	6	0.009
	310 - 315	Permian	Betts Creek Beds	coal - C-Seam	5	0.004
	318 - 323	Permian	Betts Creek Beds	sandstone and siltstone	4	0.009
	324.5 - 329.5	Permian	Betts Creek Beds	coal - D2-Seam	3	0.008
	336 - 339	Permian	Betts Creek Beds	coal - E Seam	2	0.008
	343 - 345	Permian	Betts Creek Beds	coal - F Seam	1	0.002
MC5046	280 - 285	Permian	Betts Creek Beds	coal - AL- Seam	6	0.003
	289 - 294	Permian	Betts Creek Beds	coal - B2-Interburden	5	0.002

Hole ID	Test interval (mbGL)	Age	Unit	Lithology	Test No.	Interpreted hydraulic conductivity (m/day)
	320.9 - 324.9	Permian	Betts Creek Beds	sandstone and siltstone	4	0.004
	324.5 - 329.5	Permian	Betts Creek Beds	coal - D2-Seam	3	0.008
	336 - 339	Permian	Betts Creek Beds	coal - E-Seam	2	0.007
	343 - 345	Permian	Betts Creek Beds	coal - F-Seam	1	0.011
MC5049	403 - 407	Permian	Betts Creek Beds	coal - D2-Seam	3	0.002
	418 - 421	Permian	Betts Creek Beds	coal - E-Seam	2	0.003
	427 - 430	Permian	Betts Creek Beds	coal - F-Seam	1	0.005
MC5051	175 - 180	Permian	Betts Creek Beds	sandstone	10	0.01
	192 - 194	Permian	Betts Creek Beds	coal - AL- Seam	6	0.007
	203 - 205	Permian	Betts Creek Beds	coal - C-Seam	5	0.006
	211 - 213	Permian	Betts Creek Beds	sandstone and siltstone	4	0.007
	248 - 250	Permian	Betts Creek Beds	coal - D2-Seam	3	0.025
	259 - 264	Permian	Betts Creek Beds	coal - E-Seam	9	0.007
	261 - 263	Permian	Betts Creek Beds	coal - E-Seam	2	0.007
	267 - 269	Permian	Betts Creek Beds	coal - F-Seam	1	0.009
	274 - 278	Permian	Betts Creek Beds	sandstone	8	0.006
MC5052	181 - 184	Triassic	Rewan Formation	sandstone	10	0.044
	292 - 296	Permian	Betts Creek Beds	sandstone	9	0.008
	310 - 313	Permian	Betts Creek Beds	coal - AU1 - Seam	8	0.04
	320.4 - 323.4	Permian	Betts Creek Beds	coal - AL- Seam	7	0.007
	328 - 331	Permian	Betts Creek Beds	coal - B-Seam	6	0.01
	337 - 340	Permian	Betts Creek Beds	coal - C-Seam	5	0.004
	354 - 358	Permian	Betts Creek Beds	sandstone and siltstone	4	0.002
	367 - 369	Permian	Betts Creek Beds	coal - D1-Seam	3	0.017
	374 - 377	Permian	Betts Creek Beds	coal - E-Seam	2	0.012
	382 - 384	Permian	Betts Creek Beds	coal - F-Seam	1	0.004

A4. Groundwater quality sampling

A4.1 Water quality sampling method

A total of 38 groundwater samples collected over two rounds were collected from 21 groundwater monitoring bores between March 2013 and April 2014. Prior to purging, groundwater depth was measured with a water level dipper. Generally, samples were collected by purging bores of a minimum three bore volumes until field parameters (pH, electrical conductivity and temperature) had stabilised. For those bores that purged dry, samples were collected once the bore recovered sufficiently to collect a sample. The monitoring bores were purged and sampled using a combination of bailer and Bennett sampling pumps.

Each sample was collected in laboratory-supplied containers. Samples requiring dissolved metal analysis were filtered in the field, using a 0.45 micron filter, prior to being transferred to the laboratory. All samples were itemised on a Chain of Custody Form, which accompanied the samples to the laboratory. The water samples were submitted to ALS Environmental Laboratories (ALS) for analysis. ALS is National Association of Testing Authorities (NATA) accredited.

A4.2 Lab water quality analysis

The water samples were analysed for the following suite of parameters:

- Physical parameters (pH, electrical conductivity, total dissolved solids, total hardness);
- Major anions (CO3, HCO3, Cl, SO4);
- Major cations (Ca, Mg, Na, K);
- Minor ions (F);
- A suite of 49 dissolved and total metals and metalloids; and
- Nutrients (ammonia, nitrite, nitrate, nitrite + nitrate, TKN, total nitrogen, total phosphorus).

Section 6.3 in the main report summarises major ion concentrations for the different groundwater units. Appendix A-3 includes the complete set of laboratory data compared against the ANZECC (2000)[5] guidelines for irrigation and livestock drinking water, as well as Australian drinking water guidelines (NHMRC, 2011)[6].

A4.3 Field water quality sampling

Field water quality measurements were recorded during each sampling event, including electrical conductivity (EC) and pH. Appendix A-3 provides the measured parameters for each sampling event. Table A 5 summarises the water quality data.

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[5] ANZECC (2000) '*Australia and New Zealand guidelines for fresh and marine water quality*', National water quality management strategy; no.4, October 2000

[6] NHMRC, NRMMC (2011) '*Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy*', National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra, Version 2.0, updated December 2013

Table A 5 Summary of water quality results – all geological units

Parameter	Statistic	Tertiary Sediments	Clematis Sandstone	Rewan Formation	Clematis/ Rewan	Betts Creek Beds Interburden	Betts Creek Beds coal seams
EC @ 25°C (µS/cm)	Avg.	724	3310	1765	618	895	2005
	Min.	506	387	295	332	713	1020
	Max.	989	6900	5290	904	1090	3180
Total Dissolved Solids (mg/L)	Avg.	470	2151	1148	402	582	1305
	Min.	329	252	192	216	463	663
	Max.	643	4480	3440	588	708	2070
pH (pH units)	Avg.	8.13	9.24	8.68	9.19	7.74	8.03
	Min.	7.93	5.77	7.62	9.02	6.74	7.80
	Max.	8.50	12.40	10.10	9.36	8.20	8.44
Calcium (mg/L)	Avg.	16	234	52	15	13	36
	Min.	7	2	2	5	10	16
	Max.	35	578	246	24	16	70
Magnesium (mg/L)	Avg.	13	21	31	8	17	35
	Min.	7	8	2	2	16	16
	Max.	20	44	109	13	18	58
Sodium (mg/L)	Avg.	100	160	260	103	134	312
	Min.	60	53	49	56	103	144
	Max.	159	275	635	150	163	494
Bicarbonate (mg/L)	Avg.	103	66	146	116	94	151
	Min.	58	12	29	44	67	72
	Max.	209	158	323	188	125	290
Chloride (mg/L)	Avg.	137	164	431	85	195	512
	Min.	85	34	35	46	159	243
	Max.	191	540	1350	124	233	743
Sulphate (mg/L)	Avg.	20	10	46	13	26	57
	Min.	10	6	2	6	21	6
	Max.	47	16	288	19	36	101
Number of Samples		**5**	**5**	**16**	**2**	**4**	**6**

A5. Bore census

A bore census was carried out between December 2012 and June 2013 at the project site and surrounding properties. The bore census was designed to identify private bores surrounding the project site that could potentially be impacted by the project. In addition, findings from a bore census conducted by GHD as part of the groundwater investigation for Carmichael Coal Mine. were also used in the assessment.

A total of 90 private bores were identified through the DNRM GWDB and through the bore census of surrounding properties. Section 6.4 of the main report outlines the results from the bore census; Appendix A-1 provides details of all of the landholder bores surrounding the project site within the domain of the groundwater model. Figure 21 in the main body of the report shows the locations of all known landholder bores surrounding the project site

Appendix A-1
Bore details

Appendix A-1 - Bore Details

Type	Bore ID	Bore Type	Easting	Northing	Surface (mAHD)	Ending Depth (mAHD)	Bore Depth (mbgl)	Target Unit	Model Layer	Yield (incl. air lifts)	Packer Testing	Head Test	Pumping Test	Field Water Quality
Project China Stone	MB03	SP	414830	7589056	346.7	254.9	91.8	A Seam	10	Y	N	Y	N	Y
Project China Stone	MB04	SP	413863	7590355	366.3	341.0	25.3	Tertiary	2	N	N	N	N	N
Project China Stone	MB05	SP	413873	7590356	366.1	258.3	107.8	Betts Creek Beds	9	N	N	Y	N	N
Project China Stone	MB06	SP	413874	7590369	366.0	229.0	137.0	A/B Seams	12	N	N	Y	N	N
Project China Stone	MB07	SP	415547	7590584	343.0	283.2	59.8	Tertiary	2	Y	N	Y	N	Y
Project China Stone	MB08	SP	415553	7590570	342.9	255.0	87.9	Betts Creek Beds	9	Y	N	Y	N	Y
Project China Stone	MB09	SP	414434	7592831	342.2	319.1	23.2	Tertiary	2	N	N	N	N	N
Project China Stone	MB10	SP	414439	7592830	342.1	285.0	57.2	Betts Creek Beds	9	Y	N	Y	N	Y
Project China Stone	MB11	SP	414442	7592837	341.9	258.8	83.1	A/B Seams	12	Y	N	Y	N	Y
Project China Stone	MB12	SP	410626	7590113	376.9	274.9	102.0	Rewan Formation	8	N	N	Y	N	N
Project China Stone	MB13	SP	408638	7594223	389.1	287.7	101.4	Rewan Formation	8	Y	N	Y	N	Y
Project China Stone	MB14	SP	407589	7598323	446.3	300.3	146.0	Rewan Formation	8	Y	N	Y	N	Y
Project China Stone	MB15	SP	409522	7602328	408.7	293.5	115.2	Rewan Formation	8	N	N	Y	N	N
Project China Stone	MB16	SP	417115	7585134	329.0	304.2	24.8	Tertiary	2	N	N	N	N	N
Project China Stone	MB17	SP	417118	7585137	329.0	252.3	76.7	Tertiary	2	N	N	Y	N	N
Project China Stone	MB18	SP	414442	7583778	341.5	289.1	52.4	Tertiary	2	N	N	N	N	N
Project China Stone	MB19	SP	414446	7583780	341.5	261.2	80.3	Rewan Formation	8	Y	N	Y	N	Y
Project China Stone	MB20	SP	420926	7589917	297.3	272.5	24.8	Tertiary	2	N	N	N	N	N
Project China Stone	MB21	SP	407809	7592771	470.4	340.0	130.4	Clematis Sandstone	5	N	N	N	N	N
Project China Stone	MB22	SP	409254	7588046	388.0	280.6	107.4	Clematis Sandstone	5	N	N	Y	N	N
Project China Stone	MB23	SP	410019	7595392	415.7	325.7	90.0	Rewan Formation	8	N	N	N	N	N
Project China Stone	MB24	SP	408081	7596736	440.0	310.2	129.8	Rewan Formation	8	N	N	Y	N	N
Project China Stone	MB25	SP	407410	7596980	462.0	318.7	143.3	Rewan Formation	8	N	N	N	N	N
Project China Stone	MB26	SP	407115	7601043	410.6	291.8	118.8	Rewan Formation	8	Y	N	N	N	Y
Project China Stone	MB27	SP	407959	7600572	415.2	302.2	113.0	Rewan Formation	8	N	N	Y	N	N
Project China Stone	MB28	SP	409796	7599783	436.5	298.7	137.8	Rewan Formation	8	N	N	Y	N	N
Project China Stone	MB29	SP	407367	7608867	496.1	348.1	148.0	Clematis Sandstone	5	N	N	N	N	N
Project China Stone	MB30	SP	409939	7609491	483.6	334.3	149.3	Clematis Sandstone	5	N	N	N	N	N
Project China Stone	MB31	SP	406705	7613342	468.6	318.6	150.0	Clematis Sandstone	5	N	N	N	N	N
Project China Stone	MB32	SP	420524	7590538	302.1	277.3	24.8	Tertiary	2	N	N	N	N	N
Project China Stone	MB33	SP	407079	7604221	417.8	268.0	149.8	Clematis SS / Rewan Fm	7	N	N	Y	N	N
Project China Stone	VWP1_1	VWP	410643	7590108	385.0	-		Rewan Formation	8	N	Y	N	N	N
Project China Stone	VWP1_2	VWP	410643	7590108	385.0	-		Betts Creek Beds	9	N	Y	N	N	N
Project China Stone	VWP1_3	VWP	410643	7590108	385.0	-		AU Seam	10	N	Y	N	N	N
Project China Stone	VWP2_1	VWP	408642	7594211	398.0	-		Betts Creek Beds	9	N	Y	N	N	N
Project China Stone	VWP2_2	VWP	408642	7594211	398.0	-		A Seam	10	N	Y	N	N	N
Project China Stone	VWP2_3	VWP	408642	7594211	398.0	-		Betts Creek Beds	11	N	Y	N	N	N
Project China Stone	VWP3_1	VWP	407578	7598319	458.0	-		Rewan Formation	8	N	Y	N	N	N
Project China Stone	VWP3_2	VWP	407578	7598319	458.0	-		Betts Creek Beds	9	N	Y	N	N	N
Project China Stone	VWP3_3	VWP	407578	7598319	458.0	-		Betts Creek Beds	9	N	Y	N	N	N
Project China Stone	VWP4_1	VWP	409533	7602316	418.0	-		Rewan Formation	8	N	Y	N	N	N
Project China Stone	VWP4_2	VWP	409533	7602316	418.0	-		Rewan Formation	8	N	Y	N	N	N
Project China Stone	VWP4_3	VWP	409533	7602316	418.0	-		Rewan Formation	8	N	Y	N	N	N

Note: Coordinates are in GDA 94 Zone 55

SP : Standpipe

VWP : Vibrating wire piezometer

LHB : Landholder bore

Appendix A-1 - Bore Details

Type	Bore ID	Bore Type	Easting	Northing	Surface (mAHD)	Ending Depth (mAHD)	Bore Depth (mbgl)	Target Unit	Model Layer	Yield (incl. air lifts)	Packer Testing	Head Test	Pumping Test	Field Water Quality
Private bore	RN2207	LHB	391027	7549656	295.5	-		Tertiary?	2	N	N	N	N	-
Private bore	RN2221	LHB	374085	7551274	378.6	-		Tertiary?	2	N	N	N	N	-
Private bore	RN2229	LHB	374193	7553480	386.8	-		Tertiary?	2	N	N	N	N	-
Private bore	RN5965	LHB	381254	7550613	325.3	247.9	77.4	Moolayember Fmt	4	N	N	N	N	-
Private bore	RN6150	LHB	397931	7547994	289.0	151.8	137.2	Ronlow Beds	3	N	N	N	N	-
Private bore	RN8506	LHB	393044	7555350	301.0	-		Moolayember Fmt	4	N	N	N	N	-
Private bore	RN16371	LHB	370461	7574850	352.0	275.8	76.2	Ronlow Beds	3	N	N	N	N	-
Private bore	RN16830	LHB	394117	7545745	289.4	130.9	158.5	Moolayember Fmt	4	N	N	N	N	-
Private bore	RN16895	LHB	410061	7561628	257.4	159.9	97.5	Clematis Sandstone	5	N	N	N	N	-
Private bore	RN16896	LHB	406868	7558257	272.5	149.1	123.4	Clematis Sandstone	5	N	N	N	N	-
Private bore	RN17980	LHB	426849	7565142	278.7	223.8	54.9	Rewan Formation	8	N	N	N	N	-
Private bore	RN17981	LHB	423527	7576054	289.7	228.7	61.0	Rewan Formation	8	N	N	N	N	-
Private bore	RN17982	LHB	433592	7565399	240.7	189.6	51.1	Betts Creek Beds	17	N	N	N	N	-
Private bore	RN22367	LHB	394416	7545886	289.4	-56.9	346.3	Moolayember Fmt	4	N	N	N	N	-
Private bore	RN25500	LHB	378076	7563350	327.8	-		Moolayember Fmt	4	N	N	N	N	-
Private bore	RN32980	LHB	376195	7595709	378.2	349.3	28.9	Ronlow Beds	3	N	N	N	N	-
Private bore	RN36400	LHB	419234	7589965	311.9	-		Joe Joe Group	9	N	N	N	N	-
Private bore	RN36401	LHB	435204	7587181	257.0	194.5	62.5	Joe Joe Group	9	N	N	N	N	-
Private bore	RN39801	LHB	401187	7569715	292.2	200.7	91.5	Moolayember Fmt	4	N	N	N	N	-
Private bore	RN39802	LHB	393849	7571397	294.7	120.3	174.4	Moolayember Fmt	4	N	N	N	N	-
Private bore	RN44485	LHB	438998	7546581	261.2	-		Tertiary?	2	Y	N	N	N	-
Private bore	RN47167	LHB	432099	7559599	269.3	222.1	47.2	Clematis Sandstone	5	N	N	N	N	-
Private bore	RN47637	LHB	431780	7594906	273.2	-		Basement Volcanics	17	N	N	N	N	-
Private bore	RN47639	LHB	425622	7615420	295.5	291.2	4.3	Betts Creek Beds	9	N	N	N	N	-
Private bore	RN54627	LHB	382895	7570700	341.2	339.2	2.0	Tertiary	2	N	N	N	N	-
Private bore	RN62623	LHB	442969	7545554	236.5	169.5	67.0	Dunda Beds	6	Y	N	N	N	-
Private bore	RN62624	LHB	439404	7546336	256.0	202.0	54.0	Tertiary	2	Y	N	N	N	-
Private bore	RN62754	LHB	418833	7548212	266.3	-		Tertiary?	2	N	N	N	N	-
Private bore	RN70308	LHB	439280	7619223	264.0	-		Tertiary?	2	N	N	N	N	-
Private bore	RN76888	LHB	377991	7563196	327.8	245.5	82.3	Moolayember Formation	4	N	N	N	N	-
Private bore	RN89072	LHB	426589	7598813	326.4	283.7	42.7	Tertiary	2	N	N	N	N	-
Private bore	RN89073	LHB	436107	7597782	341.1	290.8	50.3	Alluvium	1	N	N	N	N	-
Private bore	RN90255	LHB	419633	7577047	330.3	235.3	95.0	Clematis Sandstone	5	N	N	N	N	-
Private bore	RN90256	LHB	423671	7580878	280.0	162.6	117.4	Joe Joe Group	9	Y	N	N	N	-
Private bore	RN90257	LHB	442360	7576313	231.2	111.2	120.0	Joe Joe Group	17	N	N	N	N	-
Private bore	RN90258	LHB	426775	7565785	282.2	206.9	75.3	Clematis Sandstone	5	Y	N	N	N	-
Private bore	RN90259	LHB	423688	7577246	290.0	185.0	104.9	Rewan Formation	8	N	N	N	N	-
Private bore	RN90260	LHB	436157	7551360	260.0	169.0	91.0	Rewan Formation	8	N	N	N	N	-
Private bore	RN90369	LHB	431919	7560469	281.1	202.1	79.0	Tertiary	2	Y	N	N	N	-
Private bore	RN96545	LHB	400295	7571749	293.6	59.6	234.0	Moolayember Fmt	4	N	N	N	N	-
Private bore	RN100185	LHB	381554	7554876	330.6	327.6	3.0	Tertiary	2	N	N	N	N	-
Private bore	RN102615	LHB	383407	7628532	310.0	234.3	75.8	Moolayember Fmt	4	N	N	N	N	-
Private bore	RN102616	LHB	383296	7626814	301.6	238.0	63.6	Moolayember Fmt	4	N	N	N	N	-
Private bore	RN103877	LHB	425379	7607254	331.4	241.4	90.0	Betts Creek Beds	9	N	N	N	N	-
Private bore	RN103878	LHB	426591	7614110	290.6	228.7	61.8	Alluvium	1	Y	N	N	N	-
Private bore	RN118213	LHB	383472	7570354	325.4	237.6	87.8	Moolayember Fmt	4	Y	N	N	N	-
Private bore	RN118253	LHB	389570	7554808	309.0	307.0	2.0	Tertiary	2	Y	N	N	N	-
Private bore	RN118645	LHB	374942	7547645	355.3	353.3	2.0	Ronlow Beds	3	Y	N	N	N	-
Private bore	RN132938	LHB	423989	7574860	285.8	138.8	147.0	Betts Creek Beds	9	Y	N	N	N	-
Private bore	RN132939	LHB	442391	7547815	230.8	121.8	109.0	Betts Creek Beds?	9	Y	N	N	N	-
Private bore	RN132940	LHB	430302	7566901	252.6	209.2	43.4	Tertiary	2	N	N	N	N	-
Private bore	RN132941	LHB	420989	7573964	297.6	231.6	66.0	Tertiary	2	Y	N	N	N	-
Private bore	RN132942	LHB	432461	7557893	246.8	180.8	66.0	Tertiary	2	Y	N	N	N	-
Private bore	RN132943	LHB	436542	7549885	266.3	193.1	73.2	Tertiary	2	Y	N	N	N	-
Private bore	RN153491 (Bonsai bore)	LHB	401317	7622968	366.3	281.3	85.0	Clematis Sandstone	5	Y	N	N	N	-
Private bore	RN153581	LHB	395472	7599422	-	100.0	100.0	Clematis Sandstone?	5	Y	N	N	N	-
Private bore	RN153582	LHB	403774	7583208	-	121.0	121.0	Clematis Sandstone?	5	Y	N	N	N	-
Private bore	RN153583	LHB	401055	7600393	-	97.0	97.0	Clematis Sandstone?	5	Y	N	N	N	-
Private bore	RN158036	LHB	427560	7556220	237.9	-	-	Alluvium?	1	N	N	N	N	-
Private bore	RN158037	LHB	427565	7556214	237.9	-	-	Alluvium?	1	N	N	N	N	-
Private bore	RN158038	LHB	433645	7554823	234.2	-	-	Alluvium?	1	N	N	N	N	-
Private bore	50000 Bore	LHB	434904	7594662	302.5	254.9	47.6	Tertiary	2	Y	N	N	N	-
Private bore	8 Mile Bore	LHB	397808	7606133	338.7	-	-	Moolayember Fmt	4	Y	N	N	N	-
Private bore	Allens Bore	LHB	430014	7585765	265.6	-	-	Tertiary?	2	N	N	N	N	-
Private bore	RN8520 (Big Bore)	LHB	394499	7591314	323.4	95.4	228.0	Moolayember Fmt	4	N	N	N	N	-
Private bore	Bore Hole	LHB	425018	7596787	301.7	-	-	Joe Joe Group	9	N	N	N	N	-
Private bore	Brumby Hole	LHB	419476	7598953	331.0	248.4	82.6	Tertiary/Joe Joe Group	2	Y	N	N	N	-
Private bore	Bully Hut 1	LHB	426317	7614304	290.9	271.9	19.1	Joe Joe Group	9	Y	N	N	N	-
Private bore	Bully Hut 2	LHB	426317	7614304	290.9	238.6	52.3	Joe Joe Group	9	N	N	N	N	-
Private bore	RN103876 (Camp Bore)	LHB	416315	7592174	333.1	259.0	74.1	Betts Creek Beds	9	N	N	N	N	-
Private bore	Dinner Creek Bore	LHB	397286	7611035	343.3	-	-	Moolayember Fmt	4	N	N	N	N	-
Private bore	Double Bore	LHB	441061	7587115	240.2	-	-	Tertiary?	2	N	N	N	N	-
Private bore	Edgers Bore	LHB	427723	7587725	275.6	-	-	Tertiary?	2	N	N	N	N	-
Private bore	Gum Hole	LHB	425174	7596844	307.0	263.1	43.9	Tertiary	2	Y	N	N	N	-
Private bore	Lane Bore	LHB	374411	7603855	344.8	284.8	60.0	Moolayember Fmt	4	Y	N	N	N	-
Private bore	Lin Bore	LHB	424923	7591009	288.6	-	-	Tertiary?	2	N	N	N	N	-
Private bore	Lin Yards	LHB	425457	7590678	286.0	-	-	Tertiary?	2	N	N	N	N	-
Private bore	Lofties Bore	LHB	424220	7603658	323.8	240.8	83.0	Tertiary/Joe Joe Group	2	Y	N	N	N	-
Private bore	RN17451 (Moonoomoo Bore)	LHB	402814	7584618	322.0	256.2	65.8	Moolayember Fmt	4	Y	N	N	N	-
Private bore	Old Windmill	LHB	436733	7589584	255.9	-	-	Tertiary?	2	N	N	N	N	-
Private bore	Pidgenhole	LHB	424286	7594242	298.1	-	-	Tertiary?	2	N	N	N	N	-
Private bore	Prestons Bore	LHB	393555	7626959	337.1	275.5	61.7	Clematis Sandstone	5	N	N	N	N	-
Private bore	RN103875 (Roo Bore)	LHB	415439	7588709	343.0	264.7	78.3	Betts Creek Beds	9	N	N	N	N	-
Private bore	RN89071 (Stallion Bore)	LHB	434834	7605336	271.2	227.9	43.3	Tertiary	2	Y	N	N	N	-
Private bore	Swamp Bore	LHB	389547	7626125	321.0	266.0	55.0	Clematis Sandstone	5	Y	N	N	N	-
Private bore	Tomahalk	LHB	432126	7588667	266.8	-	-	Joe Joe Group	9	N	N	N	N	-
Private bore	Tomahawk No. 1	LHB	430781	7596452	279.0	-	-	Tertiary?	2	N	N	N	N	-
Private bore	Tomahawk No. 2	LHB	430781	7596446	279.0	258.4	20.6	Tertiary	2	Y	N	N	N	-
Private bore	RN47640 (Tomahawk Hut)	LHB	431986	7594800	273.2	251.5	21.7	Tertiary	2	Y	N	N	N	-
Private bore	Tutor Bore	LHB	390274	7617085	308.9	185.5	123.4	Moolayember Fmt	4	N	N	N	N	-
Private bore	Wild Bore	LHB	415707	7574936	303.4	-	-	Clematis Sandstone?	5	N	N	N	N	-

Note: Coordinates are in GDA 94 Zone 55
SP : Standpipe
VWP : Vibrating wire piezometer
LHB : Landholder bore

Appendix A-1 - Bore Details

Type	Bore ID	Bore Type	Easting	Northing	Surface (mAHD)	Ending Depth (mAHD)	Bore Depth (mbgl)	Target Unit	Model Layer	Yield (incl. air lifts)	Packer Testing	Head Test	Pumping Test	Field Water Quality
Private bore	Warratah Camp Bore	LHB	414226	7576678	316.0	238.0	78.0	Clematis Sandstone	5	Y	N	N	N	-
Carmichael bore	C006P1	SP	435726	7560833	233.7	-	-	Interburden	15	-	-	-	-	-
Carmichael bore	C006P3r	SP	435734	7560826	233.9	-	-	D Seam	16	-	-	-	-	-
Carmichael bore	C007P2	SP	434726	7559864	238.1	-	-	AB Seam	12	-	-	-	-	-
Carmichael bore	C007P3	SP	434728	7559862	238.1	-	-	D Seam	16	-	-	-	-	-
Carmichael bore	C008P1	SP	433710	7558830	238.1	-	-	Permian	9	-	-	-	-	-
Carmichael bore	C008P2	SP	433708	7558827	238.1	-	-	AB Seam	12	-	-	-	-	-
Carmichael bore	C011P1	SP	428843	7569953	254.5	-	-	Interburden	13	-	-	-	-	-
Carmichael bore	C011P3	SP	428846	7569955	254.4	-	-	D Seam	16	-	-	-	-	-
Carmichael bore	C012P1	SP	430888	7569874	247.3	-	-	Permian Overburden	9	-	-	-	-	-
Carmichael bore	C012P2	SP	430887	7569877	247.3	-	-	Permian Overburden	9	-	-	-	-	-
Carmichael bore	C014P2	SP	430731	7563976	256.0	-	-	AB Seam	12	-	-	-	-	-
Carmichael bore	C016P2	SP	422017	7574974	294.5	-	-	AB Seam	12	-	-	-	-	-
Carmichael bore	C018P1	SP	423982	7574850	281.3	-	-	Permian Overburden	9	-	-	-	-	-
Carmichael bore	C018P2	SP	423988	7574849	281.3	-	-	AB Seam	12	-	-	-	-	-
Carmichael bore	C018P3	SP	423978	7574853	281.2	-	-	D Seam	16	-	-	-	-	-
Carmichael bore	C020P2	SP	427846	7566932	263.1	-	-	AB Seam	12	-	-	-	-	-
Carmichael bore	C022P1	SP	426813	7565962	273.8	-	-	Dunda Beds	6	-	-	-	-	-
Carmichael bore	C024P3	SP	428909	7571761	258.6	-	-	D Seam	16	-	-	-	-	-
Carmichael bore	C025P1	SP	438016	7555846	227.5	-	-	Tertiary	2	-	-	-	-	-
Carmichael bore	C025P2	SP	438010	7555845	227.5	-	-	Tertiary	2	-	-	-	-	-
Carmichael bore	C027P1	SP	433643	7554818	227.0	-	-	Alluvium	1	-	-	-	-	-
Carmichael bore	C027P2	SP	433648	7554819	227.6	-	-	Dunda Beds	6	-	-	-	-	-
Carmichael bore	C029P1	SP	437691	7555082	225.4	-	-	Tertiary	2	-	-	-	-	-
Carmichael bore	C029P2	SP	437688	7555081	225.4	-	-	Alluvium	1	-	-	-	-	-
Carmichael bore	C032P2	SP	439404	7544896	256.2	-	-	Permian Overburden	9	-	-	-	-	-
Carmichael bore	C034P1	SP	442386	7547816	227.4	-	-	AB Seam	12	-	-	-	-	-
Carmichael bore	C034P3	SP	442389	7547814	227.4	-	-	D Seam	16	-	-	-	-	-
Carmichael bore	C035P1	SP	441404	7546824	236.3	-	-	Rewan Formation	8	-	-	-	-	-
Carmichael bore	C035P2	SP	441402	7546828	236.2	-	-	AB Seam	12	-	-	-	-	-
Carmichael bore	C555P1	SP	432450	7557881	241.2	-	-	Rewan Formation	8	-	-	-	-	-
Carmichael bore	C556P1	SP	436524	7549882	260.6	-	-	Rewan Group	8	-	-	-	-	-
Carmichael bore	C558P1	SP	430312	7566903	250.1	-	-	Tertiary / Permian	2	-	-	-	-	-
Carmichael bore	C9553P1R	SP	421010	7573975	294.1	-	-	Dunda Beds	6	-	-	-	-	-
Carmichael bore	HD01	SP	426146	7561468		-	-	Dunda Beds	6	-	-	-	-	-
Carmichael bore	HD02	SP	423823	7557008	240.0	-	-	Clematis Sandstone	5	-	-	-	-	-
Carmichael bore	HD03A	SP	427565	7556120	229.4	-	-	Dunda Beds	6	-	-	-	-	-
Carmichael bore	HD03B	SP	427559	7556119	229.4	-	-	Alluvium	1	-	-	-	-	-
Carmichael bore	C553P_1	VWP	420993	7573965	294.6	-	-	D1 Seam	16	-	-	-	-	-
Carmichael bore	C553P_2	VWP	420993	7573965	294.6	-	-	AB1 Seam	10	-	-	-	-	-
Carmichael bore	C553P_3	VWP	420993	7573965	294.6	-	-	Permian Overburden	9	-	-	-	-	-
Carmichael bore	C555P_1	VWP	432450	7557881	241.2	-	-	D Seam	16	-	-	-	-	-
Carmichael bore	C555P_2	VWP	432450	7557881	241.2	-	-	AB1 Seam	10	-	-	-	-	-
Carmichael bore	C555P_3	VWP	432450	7557881	241.2	-	-	Rewan Group	8	-	-	-	-	-
Carmichael bore	C9556PR_1	VWP	436543	7549885	260.4	-	-	D2 Seam	16	-	-	-	-	-
Carmichael bore	C9556PR_2	VWP	436543	7549885	260.4	-	-	AB1 Seam	10	-	-	-	-	-
Carmichael bore	C9556PR_3	VWP	436543	7549885	260.4	-	-	Rewan Group	8	-	-	-	-	-
Carmichael bore	C056C_1	VWP	424920	7569970	283.9	-	-	D1 Seam	16	-	-	-	-	-
Carmichael bore	C056C_2	VWP	424920	7569970	283.9	-	-	AB1 Seam	10	-	-	-	-	-
Carmichael bore	C056C_3	VWP	424920	7569970	283.9	-	-	Rewan Group	6	-	-	-	-	-
Carmichael bore	C558P_1	VWP	430312	7566903	250.1	-	-	Overburden	17	-	-	-	-	-
Carmichael bore	C558P_2	VWP	430312	7566903	250.1	-	-	D1 Seam	16	-	-	-	-	-
Carmichael bore	C558P_3	VWP	430312	7566903	250.1	-	-	AB1 Seam	10	-	-	-	-	-
Carmichael bore	C823SP	SP	433605	7562875	245.9	-	-	C Seam	14	-	-	-	-	-
Carmichael bore	C825SP	SP	434868	7561960	238.1	-	-	D Seam Underburden	17	-	-	-	-	-
Carmichael bore	C827SP	SP	436101	7560334	231.7	-	-	E Seam	17	-	-	-	-	-
Carmichael bore	C829SP	SP	436463	7559356	238.1	-	-	Colinlea sandstone	17	-	-	-	-	-
Carmichael bore	C180112SP	SP	437715	7558820	226.2	-	-	Colinlea sandstone	17	-	-	-	-	-
Carmichael bore	C180114SP	SP	438687	7557649	225.0	-	-	D Seam	16	-	-	-	-	-
Carmichael bore	C832SP	SP	439570	7554788	223.1	-	-	C Seam	14	-	-	-	-	-
Carmichael bore	C833SP	SP	439559	7554779	223.1	-	-	D Seam	16	-	-	-	-	-
Carmichael bore	C834SP	SP	439577	7554764	223.1	-	-	D Seam Underburden	17	-	-	-	-	-
Carmichael bore	C836VWP_1	VWP	437567	7552869	236.8	-	-	Interburden	13	-	-	-	-	-
Carmichael bore	C836VWP_2	VWP	437567	7552869	236.8	-	-	AB Seam	10	-	-	-	-	-
Carmichael bore	C836VWP_3	VWP	437567	7552869	236.8	-	-	Overburden	9	-	-	-	-	-
Carmichael bore	C9838SPR	SP	439558	7552813	228.6	-	-	Overburden	9	-	-	-	-	-
Carmichael bore	C9839SPR	SP	439567	7552797	228.3	-	-	Interburden	13	-	-	-	-	-
Carmichael bore	C840SP	SP	439546	7552839	228.7	-	-	Interburden	13	-	-	-	-	-
Carmichael bore	C842VWP_1	VWP	439502	7550839	238.8	-	-	Interburden	13	-	-	-	-	-
Carmichael bore	C842VWP_2	VWP	439502	7550839	238.8	-	-	AB Seam	12	-	-	-	-	-
Carmichael bore	C842VWP_3	VWP	439502	7550839	238.8	-	-	Rewan Group	8	-	-	-	-	-
Carmichael bore	C844SP	SP	441392	7546840	235.6	-	-	Interburden	13	-	-	-	-	-
Carmichael bore	C9845SPR	SP	439412	7544904	255.2	-	-	Rewan Group	8	-	-	-	-	-
Carmichael bore	C847SP	SP	442385	7543809	236.8	-	-	Interburden	13	-	-	-	-	-
Carmichael bore	C848SP	SP	442364	7543815	236.7	-	-	D Seam	16	-	-	-	-	-
Carmichael bore	C9849SPR	SP	442357	7543819	236.9	-	-	Below D Seam	17	-	-	-	-	-
Carmichael bore	C851VWP_1	VWP	441383	7542878	244.7	-	-	Interburden	13	-	-	-	-	-
Carmichael bore	C851VWP_2	VWP	441383	7542878	244.7	-	-	AB3	12	-	-	-	-	-
Carmichael bore	C851VWP_3	VWP	441383	7542878	244.7	-	-	Permian Overburden	9	-	-	-	-	-
Carmichael bore	C180119SP	SP	448587	7536354	219.0	-	-	Claystone	9	-	-	-	-	-
Carmichael bore	C180122SP	SP	448581	7536351	219.0	-	-	Claystone	9	-	-	-	-	-
Carmichael bore	C9180124SPR	SP	448600	7536358	219.0	-	-	Alluvium	1	-	-	-	-	-
Carmichael bore	C180120SP	SP	447057	7531730	227.1	-	-	Alluvium	1	-	-	-	-	-
Carmichael bore	C9180125SPR	SP	447040	7531739	227.1	-	-	Alluvium	1	-	-	-	-	-
Carmichael bore	C9180121SPR	SP	448086	7529364	229.8	-	-	Mudstone	9	-	-	-	-	-
Carmichael bore	C180123SP	SP	448079	7529358	229.9	-	-	Claystone	9	-	-	-	-	-
Carmichael bore	C180116SP	SP	439394	7540911	260.7	-	-	Dunda Beds	6	-	-	-	-	-
Carmichael bore	C180117SP	SP	435917	7547523	278.6	-	-	-	-	-	-	-	-	-
Carmichael bore	C180118SP	SP	423799	7568089	305.6	-	-	-	-	-	-	-	-	-

Note: Coordinates are in GDA 94 Zone 55
SP : Standpipe
VWP : Vibrating wire piezometer
LHB : Landholder bore

Appendix A-2

Bore construction logs

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

page:1 of 1

MB03

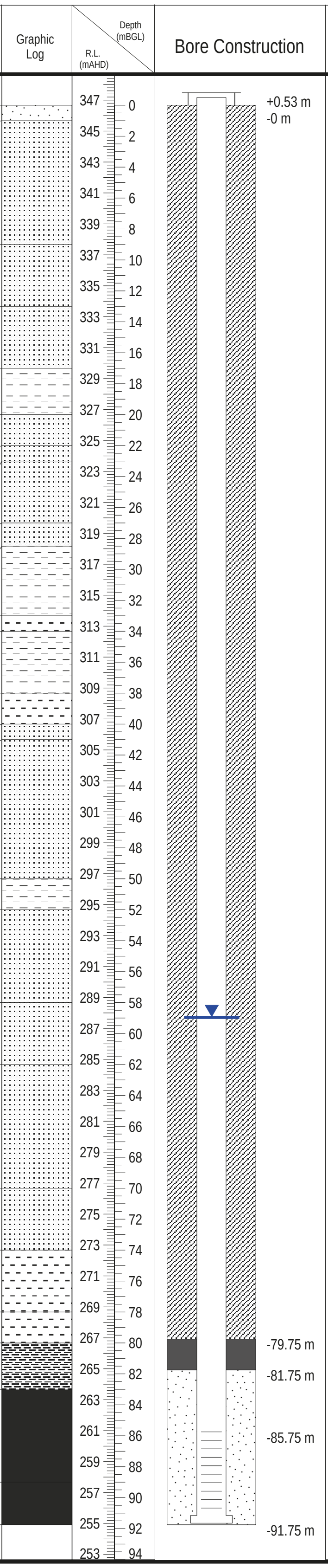
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **5-Jun-13**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Eastern Drilling**
LICENCED DRILLER: **C. Lappin (3363)**
DRILLING METHOD: **Air Rotary**

SITE ID: **I12**
EASTING: **414830.06 mE**
NORTHING: **7589056.32 mN**
DATUM: **GDA94 (z55)**
RL: **346.67 mAHD**
TD: **91.75 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SAND: Fine grained, light, red, extremely weathered
	SANDSTONE: Fine grained, light, reddish, brown, extremely
	SANDSTONE: Coarse grained, light, reddish, brown, quartzose, extremely weathered
	SANDSTONE: Fine grained, light, reddish, brown, distinctly weathered
	SANDSTONE & SILTSTONE: Light, brown, very fine sand, distinctly weathered
	SANDSTONE: Coarse grained, light, reddish, brown, quartzose, distinctly weathered
	SANDSTONE: Light, reddish, brown, very fine sand, distinctly weathered
	SANDSTONE: Coarse grained, light, reddish, brown, quartzose, distinctly weathered
	SANDSTONE: Light, reddish, brown, very fine sand distinctly weathered
	SANDSTONE: Light, yellowish, brown, very fine distinctly weathered
	CLAYSTONE: Light, whitish, brown, distinctly weathered
	SILTSTONE: Light, yellowish, brown, distinctly weathered
	CLAYSTONE: Light, brownish, buff, silty, near base of unit, distinctly weathered
Rewan Formation (Triassic)	SANDSTONE: very fine
	SANDSTONE: Light, brownish, buff, very fine sand, distinctly weathered
	SILTSTONE: Yellow, distinctly weathered
	SANDSTONE (50%) / SILTSTONE (50%): Light, yellowish, brown, very fine grained sand
	SANDSTONE: Fine grained, light, yellowish, brown, distinctly weathered
	SANDSTONE: Light, yellowish, brown, very fine, distinctly weathered
	SANDSTONE: Very fine grained, light, brown, distinctly weathered
Betts Creek Beds (Permian)	CLAYSTONE: Light, brownish, buff, distinctly weathered. BASE OF WEATHERING.
	CLAYSTONE: grey, fresh
A Seam	CARBONACEOUS CLAYSTONE: Dark, purplish, brown, fresh. A Seam
	COAL (70%) / TUFF (30%): Dark, whitish, grey, fresh. AU1 / AL5 Seams
	COAL: Black, tuffaceous, bands, throughout. AL4 / AL3 Seams



Bore Description

Protective lockable steel collar
PVC Stick up: 0.53 m

165 mm PCD bit: 0 m to 91.75 m

Bentonite grout: 0 m to 79.75 m

50 mm, PN18 uPVC, blank casing: 0.53 mAGL to 85.75m

SWL at 58.97 mBGL on 5th Jul 2013

airlift flow rate: ~0.2 L/s

Bentonite seal: 79.75 m to 81.75 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 81.75 m to 91.75 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 85.75 m to 91.75 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 91.75 m

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

page:1 of 1

MB04

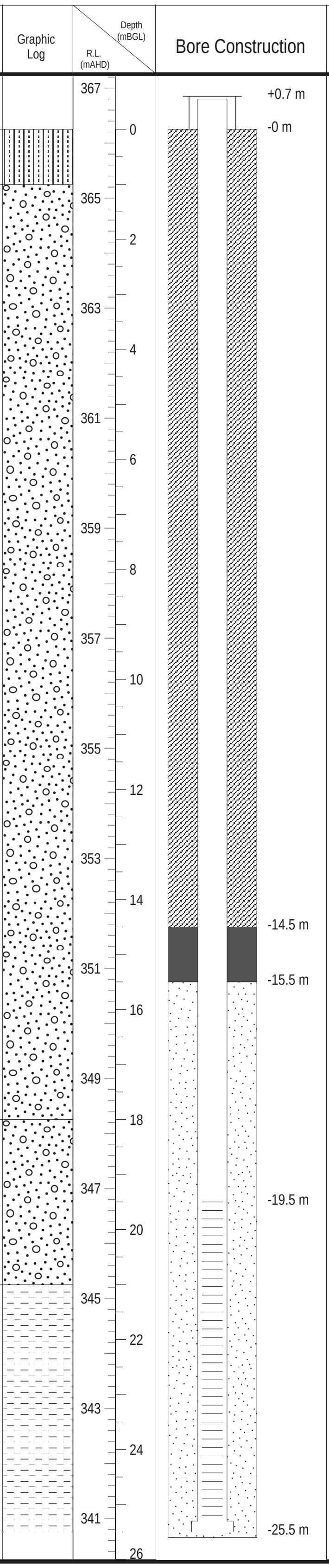
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **6-Jan-13**
LOGGED BY: **S. Miller**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **M. Rhook (3342)**
DRILLING METHOD: **Air Rotary**

SITE ID: **J14.5**
EASTING: **413863.27 mE**
NORTHING: **7590355.23 mN**
DATUM: **GDA94 (z55)**
RL: **366.25 mAHD**
TD: **25.5 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SOIL: Orangey, red, quartzose, weathered to soil
	GRAVEL CONGLOMERATE: Orangey, red, highly weathered
	GRAVEL CONGLOMERATE: Orangey, red, quartzose, fragments, throughout, highly weathered
	SILTSTONE: Orangey, red, quartzose, fragments, silty matrix



Bore Description

Protective lockable steel collar

PVC Stick up: 0.7 m

165 mm PCD bit: 0 m to 25.5 m

Bentonite grout: 0 m to 14.5 m

Bentonite seal: 14.5 m to 15.5 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 15.5 m to 25.6 m

50 mm, PN18 uPVC, blank casing: 0.5 mAGL to 19.5 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 19.5 m to 25.5 m slots opened to 1 mm every metre for stygofauna sampling

bore dry at the time of drilling, still dry on the 19th March 2014

BOC: 25.5 m

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BOREHOLE LOG

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MB05

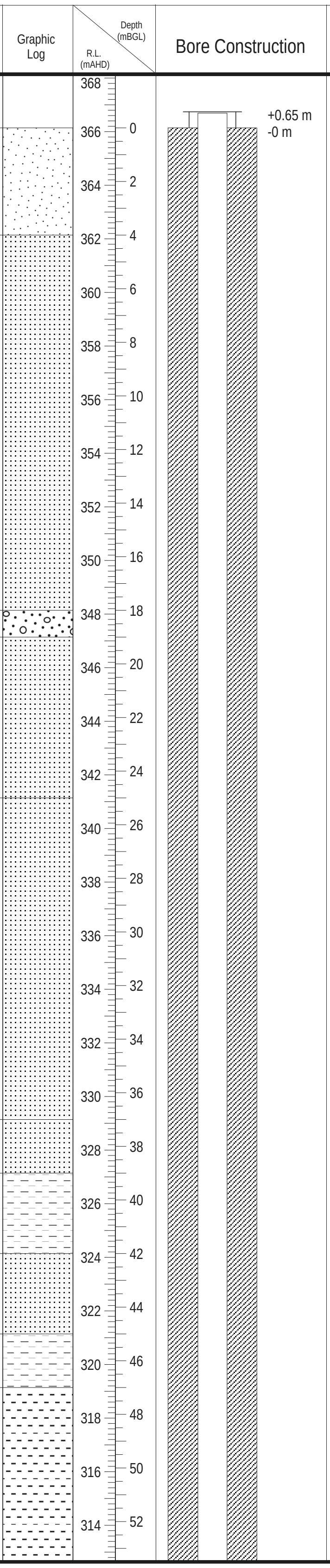
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **16-Dec-12**
LOGGED BY: **S.Miller / H.Donovan**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **M. Rhook (3342)**
DRILLING METHOD: **Air Rotary**

SITE ID: **J14.5**
EASTING: **413873.45 mE**
NORTHING: **7590356.35 mN**
DATUM: **GDA94 (z55)**
RL: **366.14 mAHD**
TD: **108 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SAND: Dark red/orange, completely weathered
	SANDSTONE: Medium red/orange, lithic, fractured, gravelly, completely weathered
	GRAVEL CONGLOMERATE: Medium grey/brown, highly weathered
	SANDSTONE: Light red/brown, minor lithic, fractured, highly weathered
	SANDSTONE: mottled red/cream, highly weathered laterite
	SANDSTONE: Very fine grained, light creamy red, highly weathered
	SILTSTONE: Light cream red, clayey, highly weathered
	SANDSTONE: Light cream white, highly weathered
	SILTSTONE: Light cream red, sandy in parts, highly weathered
	CLAYSTONE: Light creamy brown, silty in parts, moderately weathered



Bore Description

Protective lockable steel collar
PVC Stick up: 0.65 m

165 mm PCD bit: 0 m to 108 m

Bentonite grout: 0 m to 91 m

50 mm, PN18 uPVC, blank casing: 0.65 mAGL to 102 m

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BOREHOLE LOG

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MB05

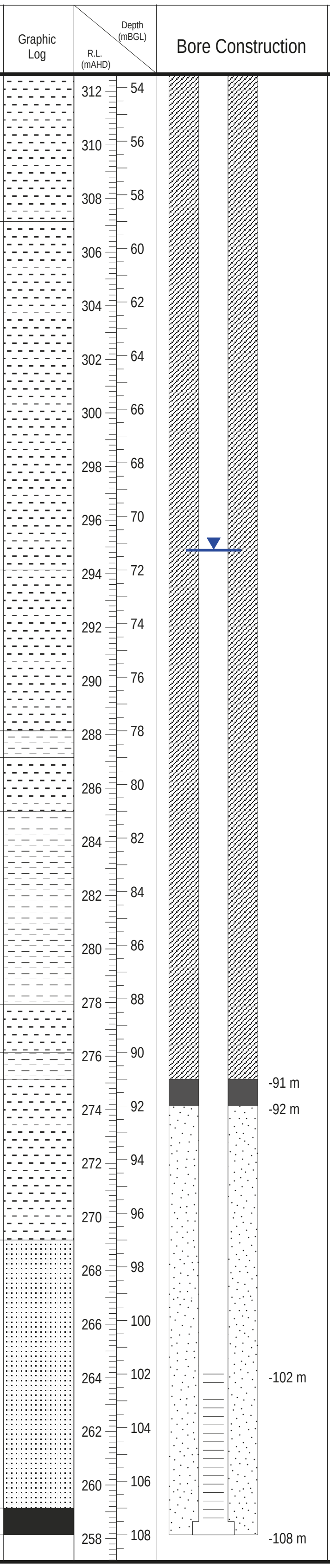
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **16-Dec-12**
LOGGED BY: **S.Miller / H.Donovan**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **M. Rhook (3342)**
DRILLING METHOD: **Air Rotary**

SITE ID: **J14.5**
EASTING: **413873.45 mE**
NORTHING: **7590356.35 mN**
DATUM: **GDA94 (z55)**
RL: **366.14 mAHD**
TD: **108 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	
Rewan Formation (Triassic)	CLAYSTONE: Light yellow/brown, moderately weathered
	CLAYSTONE: Medium purplish brown, slightly weathered
	SILTSTONE: Medium blueish grey, slightly weathered
	CLAYSTONE: Medium blueish grey, slightly weathered
	SILTSTONE: Medium blueish grey, fresh
Betts Creek Beds (Permian)	CLAYSTONE: Medium grey
	SILTSTONE: Medium grey
	CLAYSTONE: Medium grey
	SANDSTONE: Very fine grained, light grey, clayey matrix
	COAL: Dark, brown. AU4 Seam



Bore Description

SWL at 71.26 mBGL on 3rd Jul 2013

slots opened to 1 mm every metre for stygofauna sampling

Bentonite seal: 91 m to 92 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 92 m to 108 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 102 m to 108 m

BOC: 108 m

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BOREHOLE LOG

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MB06

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **19-Mar-13**
LOGGED BY: **J.Ford**

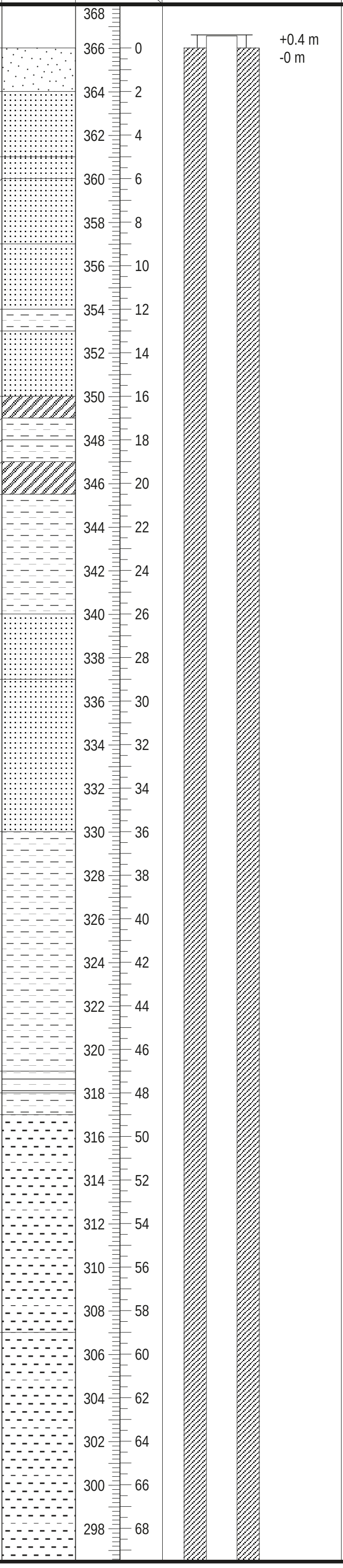
DRILLING COMPANY: **Eastern Drilling**
LICENCED DRILLER: **C.Lappin (3363)**
DRILLING METHOD: **Mud Rotary / Core**

SITE ID: **J14.5**
EASTING: **413873.53 mE**
NORTHING: **7590368.99 mN**
DATUM: **GDA94 (z55)**
RL: **366.02 mAHD**
TD: **139.5 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SAND: Medium to dark, orangy, brown, extremely, weathered.
	SANDSTONE: Medium, orange, distinctly weathered.
	SANDSTONE: Fine grained, light to medium, creamy, green, distinctly weathered.
	SANDSTONE: Medium to coarse grained, medium, brown, distinctly weathered.
	SANDSTONE: Fine grained, light to medium, reddish, brown, distinctly weathered.
	SILTSTONE: Mottled, blackish, brown, distinctly weathered.
	SANDSTONE: Fine grained, light to medium, creamy, red.
	FERRICRETE: Medium to dark, brownish, red, distinctly, weathered, abundant, quartz.
	SILTSTONE: Creamy, brown, sandy, distinctly weathered.
	SILTSTONE: Brownish, red, sandy, lithic, distinctly, weathered.
	FERRICRETE: Dark, brownish, black, altered, distinctly, weathered.
	SILTSTONE: Light to medium, reddish, brown, sandy, distinctly weathered.
	SANDSTONE: Fine grained, reddish, brown, silty, lithic, altered, distinctly weathered.
	SANDSTONE: Fine to medium grained, mottled, reddish, brown, to creamy, white, silty, distinctly weathered.
	SILTSTONE: Mottled, purplish, red, to creamy, white, clayey, lithic, distinctly weathered.
	MUDSTONE: Mottled, creamy, brown, silty, lithic, distinctly weathered.
	SILTSTONE: Mottled, yellowish, brown, clayey, distinctly, weathered.
	CLAYSTONE: Light, yellowish, brown, silty, traces, distinctly weathered.
Rewan Formation (Triassic)	CLAYSTONE: Light, yellowish, brown, silty, traces, distinctly weathered.

Graphic Log | R.L. (mAHD) | Depth (mBGL) | Bore Construction



Bore Description

Protective lockable steel collar
PVC Stick up: 0.4 m

123 mm PCD bit: 0 m to 86.3 m

HQ core: 86.3 m to 139.5 m

Reamed using 123 mm PCD bit to 139.5 m

Bentonite grout: 0 m to 105 m

50 mm, PN18 uPVC, blank casing: 0.4 mAGL to 125 m

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BOREHOLE LOG

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MB06

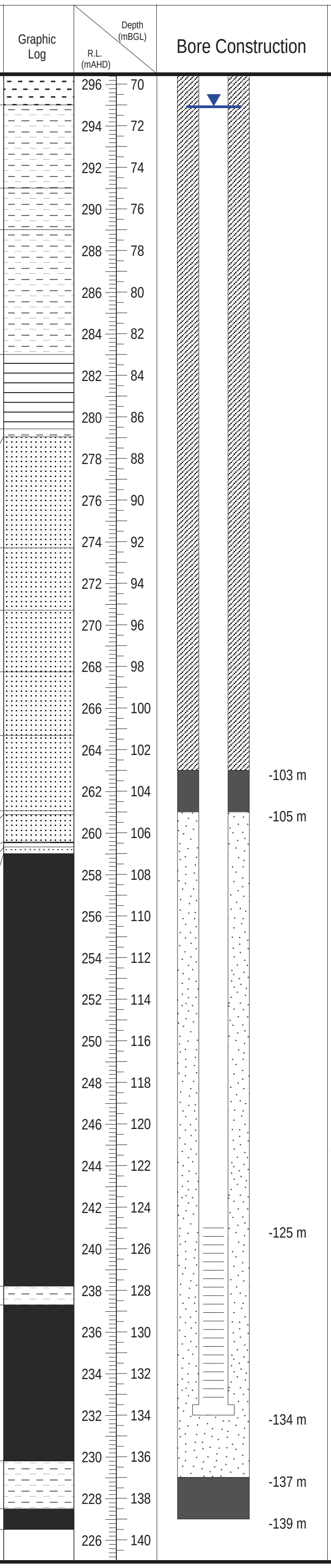
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **19-Mar-13**
LOGGED BY: **J.Ford**

DRILLING COMPANY: **Eastern Drilling**
LICENCED DRILLER: **C.Lappin (3363)**
DRILLING METHOD: **Mud Rotary / Core**

SITE ID: **J14.5**
EASTING: **413873.53 mE**
NORTHING: **7590368.99 mN**
DATUM: **GDA94 (z55)**
RL: **366.02 mAHD**
TD: **139.5 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	
	SILTSTONE: Mottled, yellowish, orange, clayey, traces, distinctly weathered.
	SILTSTONE: Mottled, purplish, brown, clayey, slightly, weathered.
	SILTSTONE: Mottled, grey, occasional, sandy, fresh.
	CORE LOSS:
	SILTSTONE: Grey, minor, sandy, phases, low strength rock, thickly laminated(6-20mm).
Betts Creek Beds (Permian)	SANDSTONE: Very fine to fine grained, light, grey, silty, laminae, throughout, low strength rock, minor, calcite, in veins, carbonaceous wisps
	SANDSTONE: Medium grained, light, grey, siltstone, laminae, near top of unit, low strength rock.
	SANDSTONE: Fine to medium grained, light, grey, carbonaceous, laminae, siltstone, lenses, low, strength rock.
	SANDSTONE: Medium grained, light, grey, carbonaceous, laminae, low strength rock.
	SANDSTONE: Fine to medium grained, light, grey, carbonaceous, laminae, low strength rock.
	SILTSTONE: Grey, low strength rock, thickly, laminated(6-20mm).
	SANDSTONE: Fine to medium grained, light, grey, siltstone, laminae.
	CORE LOSS:
A Seam	SANDSTONE: Very fine to fine grained, light, grey, siltstone, phases, throughout, low strength, rock.
	COAL: Dull <1% bright, AU4 / AL5 Seam
	SILTSTONE: Light grey, carbonaceous in part, laminated
B Seam	COAL: Dull <1% bright. B3 / B1 Seams
	SILTSTONE: Light grey, carbonaceous in part, laminated
	COAL: Dull <1% bright, C5 Seam.



Bore Description

SWL at 71.09 mBGL on 3rd Jul 2013

Bentonite seal: 103 m to 105 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 105 m to 137 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 125 m to 134 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 134 m

Bentonite seal: 137 m to 139 m

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BOREHOLE LOG

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MB07

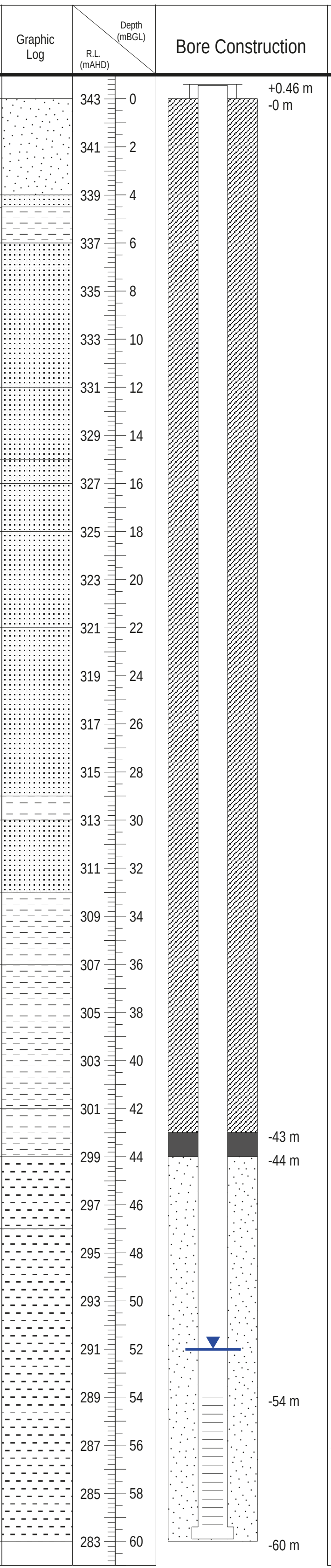
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **16-Dec-12**
LOGGED BY: **H.Donovan**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **M. Rhook (3342)**
DRILLING METHOD: **Air Rotary**

SITE ID: **K13**
EASTING: **415547.42 mE**
NORTHING: **7590583.66 mN**
DATUM: **GDA94 (z55)**
RL: **343.01 mAHD**
TD: **60 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SAND: Dark red, completely weathered. Base of Tertiary at 4 m
	SANDSTONE: Fine grained, light brown, highly weathered
	SILTSTONE: Yellow, sandy, highly weathered
	SANDSTONE: Fine grained, Yellow, highly weathered
	SANDSTONE: Very fine grained, light, yellow/grey, highly weathered
	SANDSTONE: Fine grained, light cream/red, highly weathered
	SANDSTONE: Very fine grained, light cream/grey, highly weathered
	SANDSTONE: Fine grained, reddish cream, highly weathered
	SANDSTONE: Fine grained, light cream/yellow, highly weathered
	SANDSTONE: Fine grained, light red, highly weathered
	SILTSTONE: Red, highly weathered
	SANDSTONE: Very fined grained, red, highly weathered
	SILTSTONE: Light, red/cream, highly weathered
	SILTSTONE: Light brown/red, occasional clayey sandy, highly weathered
	SILTSTONE: Light yellow, highly weathered
	CLAYSTONE: Light, white/yellow, highly weathered
	CLAYSTONE: Light, creamy pink, occasionally silty, highly weathered



Bore Description

Protective lockable steel collar
PVC Stick up: 0.46 m

152 mm PCD bit: 0 m to 60 m

Bentonite grout: 0 m to 43 m

50 mm, PN18 uPVC, blank casing: 0.46 mAGL to 54 m

Bentonite seal: 43 m to 44 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 44 m to 60 m

SWL at 52.01 mBGL on 20th Jan 2013

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 54 m to 60 m
slots opened to 1 mm every metre for stygofauna sampling

BOC: 60 m

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BOREHOLE LOG

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MB08

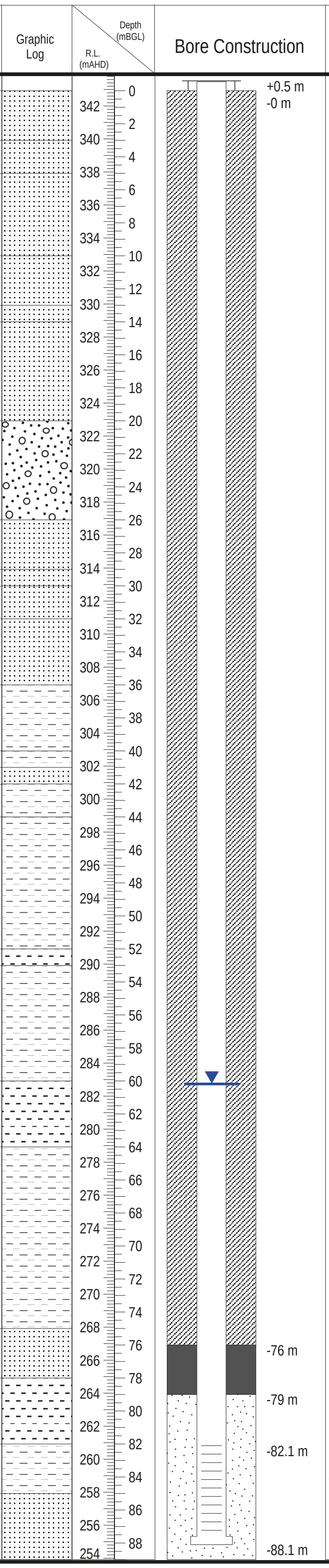
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **21-Mar-13**
LOGGED BY: **B.Diaz / H.Donovan**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **J.Freeman (3335)**
DRILLING METHOD: **Air Rotary**

SITE ID: **K13**
EASTING: **415553.1 mE**
NORTHING: **7590569.96 mN**
DATUM: **GDA94 (z55)**
RL: **342.92 mAHD**
TD: **90 mBGL**

COMMENTS: **redrill; grout seeped into the screen on the initial bore**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SAND: Red, fine grained, weathered to soil
	SANDSTONE: Reddish brown, fine grained, completely weathered
	SANDSTONE: Fine grained, yellow/brown, moderately weathered
	SANDSTONE: Medium grained, pinkish brown, moderately weathered
	SANDSTONE: Fine grained, light brown, moderately weathered
	SANDSTONE: Medium grained, reddish brown
	GRAVEL CONGLOMERATE: Light reddish brown, sandy, moderately weathered
	SANDSTONE: Fine grained, light reddish brown, moderately weathered
	SANDSTONE: Coarse grained, light reddish brown
	SANDSTONE: Fine grained, light reddish brown, moderately weathered
	SANDSTONE: Light brown, moderately weathered
	SILTSTONE: Purplish brown, clayey, moderately weathered
	SILTSTONE: light yellow, slightly weathered
	SANDSTONE: Fine grained, light yellow, slightly weathered
	SILTSTONE: Yellowish orange, slightly weathered
	SILTSTONE: Pinkish white, slightly weathered
	CLAYSTONE: Pinkish white, slightly weathered
	SILTSTONE: Off white, slightly weathered
	CLAYSTONE: Off white, yellow, slightly weathered
Betts Creek Beds (Permian)	SILTSTONE: Cream sandy towards base of unit, slightly weathered
	SANDSTONE: Medium grained, creamish grey, slightly weathered
	CLAYSTONE: Creamish grey, slightly weathered
	SILTSTONE: Grey, weathered
	SANDSTONE: Fine to medium grained, light grey, BASE OF WEATHERING AT 86.4 m.



Bore Description

Protective lockable steel collar
PVC Stick up: 0.5 m (estimate)

152 mm PCD bit: 0 m to 90 m

Bentonite grout: 0 m to 76 m

50 mm, PN18 uPVC, blank casing: 0.5 mAGL to 82.1 m

SWL at 60.18 mBGL on 30th May 2013

Bentonite seal: 76 m to 79 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 79 m to 90 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 82.1 m to 88.1 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 88.1 m

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BOREHOLE LOG

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MB09

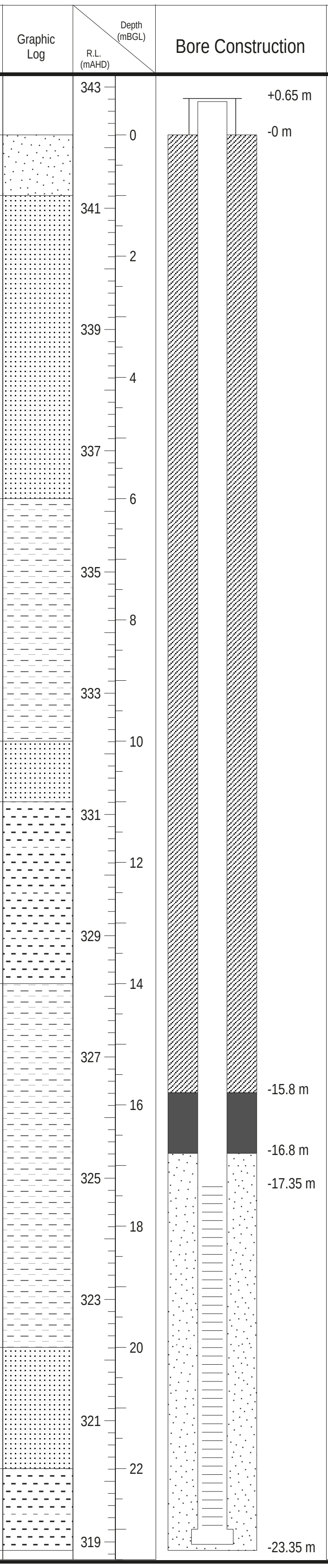
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **12-Dec-12**
LOGGED BY: **B.Diaz / H.Donovan**

DRILLING COMPANY: **Eastern Drilling**
LICENCED DRILLER: **C.Lappin (3363)**
DRILLING METHOD: **Air Rotary**

SITE ID: **LM16**
EASTING: **414433.68 mE**
NORTHING: **7592830.77 mN**
DATUM: **GDA94 (z55)**
RL: **342.21 mAHD**
TD: **23.35 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SAND: Brown
	SANDSTONE: Light pinkish red, fine to medium grained, gravelly, completely weathered
	SILTSTONE: Light pinkish purple, slightly weathered
	SANDSTONE: Very fine grained, light pinkish purple, slightly weathered
	CLAYSTONE: Light orange/brown, silty, slightly weathered
	SILTSTONE: Light orange, slightly weathered
	SANDSTONE: Very fine grained, light orange/brown, slightly weathered
Betts Creek Beds (Permian)	CLAYSTONE: Light yellow, silty, slightly weathered



Bore Description

Protective lockable steel collar

PVC Stick up: 0.65 m

165 mm PCD bit: 0 m to 23.5 m

Bentonite grout: 0 m to 15.8 m

50 mm, PN18 uPVC, blank casing: 0.65 mAGL to 15.8 m

bore dry at the time of drilling, still dry on the 30th May 2013

Bentonite seal: 15.8 m to 16.8 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 16.8 m to 23.35 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 17.35 m to 23.35 m

slots opened to 1 mm every metre for stygofauna sampling

BOC: 23.35 m

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BOREHOLE LOG

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MB10

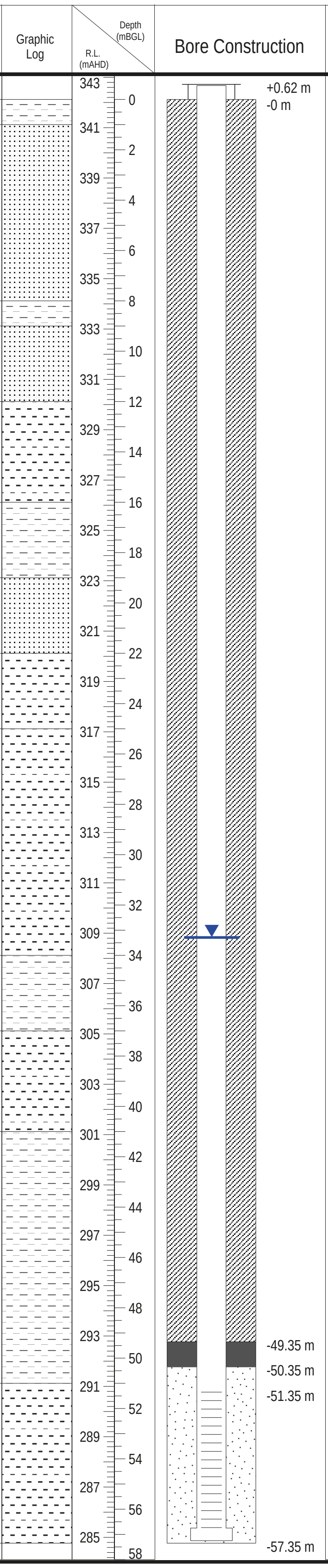
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **13-Dec-12**
LOGGED BY: **B.Diaz / H.Donovan**

DRILLING COMPANY: **Eastern Drilling**
LICENCED DRILLER: **C.Lappin (3363)**
DRILLING METHOD: **Air Rotary**

SITE ID: **LM16**
EASTING: **414439.34 mE**
NORTHING: **7592829.69 mN**
DATUM: **GDA94 (z55)**
RL: **342.12 mAHD**
TD: **57.35 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SILTSTONE: Brown, sandy, completely weathered
	SANDSTONE: Pinkish brown, fine grained, lithic fragments, moderately weathered
	SILTSTONE: Light orange, moderately weathered
	SANDSTONE: Fine grained, reddish brown, moderately weathered
	CLAYSTONE: Orange, moderately weathered
	SILTSTONE: Light orange, moderately weathered
	SANDSTONE: Very fine grained, pink, cream, moderately weathered
Betts Creek Beds (Permian)	CLAYSTONE: Orange, moderately weathered
	CLAYSTONE: Light brown/orange, slightly weathered
	SILTSTONE: light grey, fresh
	CLAYSTONE: Light grey, occasional silty
	SILTSTONE: Light grey, slightly weathered to fresh
	CLAYSTONE: Brown purplish grey, slightly weathered



Bore Description

Protective lockable steel collar
PVC Stick up: 0.62 m

165 mm PCD bit: 0 m to 57.35 m

Bentonite grout: 0 m to 49.35 m

50 mm, PN18 uPVC, blank casing: 0.62 mAGL to 51.35 m

SWL at 33.29 mBGL on 15th Dec 2013

Bentonite seal: 49.35 m to 50.35 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 50.35 m to 57.35 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 51.35 m to 57.35 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 57.35 m

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BOREHOLE LOG

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MB11

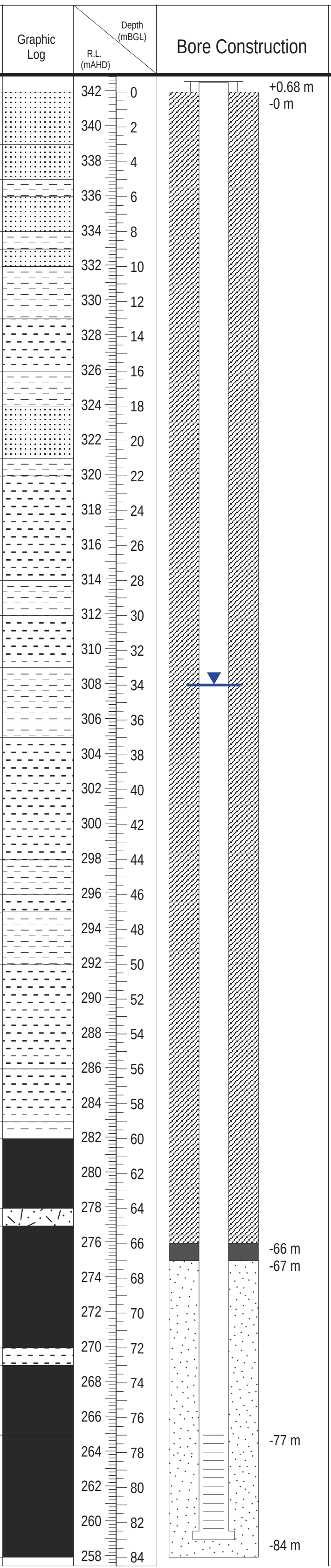
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **14-Dec-12**
LOGGED BY: **H.Donovan**

DRILLING COMPANY: **Eastern Drilling**
LICENCED DRILLER: **C.Lappin (3363)**
DRILLING METHOD: **Air Rotary**

SITE ID: **LM16**
EASTING: **414442.33 mE**
NORTHING: **7592837.12 mN**
DATUM: **GDA94 (z55)**
RL: **341.91 mAHD**
TD: **84 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SANDSTONE: Very Fine grained, yellow/red
	SANDSTONE: Fine grained, Pink/red
	SILTSTONE: Pink/orange
	SANDSTONE: Fine grained, light pink/orange
	SILTSTONE: Pink/orange
	SANDSTONE: Fine grained, light pink
	SILTSTONE: Light orange/pink
	CLAYSTONE: Light pink/yellow
	SILTSTONE: Pink
	SANDSTONE: Fine grained, light pink/yellow
	SILTSTONE: Orange/pink
Betts Creek Beds (Permian)	CLAYSTONE: Light yellow
	SILTSTONE: Orange
	CLAYSTONE: Dark yellow
	SILTSTONE: Grey
	CLAYSTONE: Grey, occasional silty
	SILTSTONE: Light grey
	CLAYSTONE: Light grey
	SILTSTONE: light grey
	CLAYSTONE: Light brown/yellow
	CLAYSTONE: Dark grey, carbonaceous in parts
	SILTSTONE: Whiteish grey
A Seam	COAL: Tuffaceous towards top of unit. AU1 / AL5 Seams
	TUFF: Occasional coaly bands
	COAL: 50% tuff. AL4 / AL3 Seams
	CARBONACEOUS CLAYSTONE: Coaly
	COAL: Tuffaceous towards top of unit AL1 Seam
B Seam	COAL: Tuffaceous towards top of unit B3 / B2 / B3 Seams



Bore Description

Protective lockable steel collar
PVC Stick up: 0.68 m

165 mm PCD bit: 0 m to 84 m

Bentonite grout: 0 m to 66 m

50 mm, PN18 uPVC, blank casing: 0.68 mAGL to 77 m

SWL at 33.99 mBGL on 21st Jan 2013

Bentonite seal: 66 m to 67 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 67 m to 84 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 77 m to 83 m
slots opened to 1 mm every metre for stygofauna sampling

BOC: 83 m

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BOREHOLE LOG

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MB12

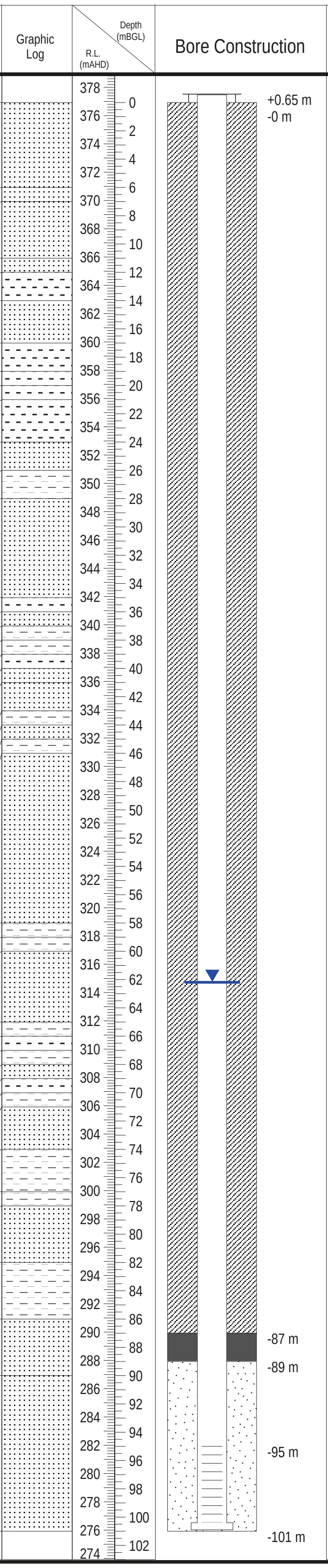
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **7-Jun-13**
LOGGED BY: **B. Walker**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Air Rotary**

SITE ID: **H16**
EASTING: **410626.14 mE**
NORTHING: **7590113.24 mN**
DATUM: **GDA94 (z55)**
RL: **376.92 mAHD**
TD: **101 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SANDSTONE: Fine grained, mottled, brown, weathered
	SANDSTONE: Very fine to fine grained, purplish, weathered
	SANDSTONE: Very fine to fine grained, creamy, weathered
	SANDSTONE: Very fine to fine grained, light, brown, weathered
	CLAYSTONE: Dark, reddish, brown, silty in part, weathered
	SANDSTONE: Very fine to fine grained, creamy, weathered
	CLAYSTONE: Dark, reddish, brown, weathered
	CLAYSTONE: Pinkish, purple, weathered
	CLAYSTONE: Dark, reddish, brown, weathered
	CLAYSTONE: Dark, purplish, brown, silty in part, weathered
	SANDSTONE: Very fine to fine grained, light, greenish, grey, weathered
	SILTSTONE: Yellowish, cream, weathered
	SANDSTONE: Very fine to fine grained, creamy, weathered
	CLAYSTONE: Brown, silty in part, weathered
	SANDSTONE: Very fine to fine grained, pinkish, cream, weathered
	SILTSTONE: Pinkish, cream, weathered
	SILTSTONE: Pinkish, weathered
	CLAYSTONE: Brown, silty in part, weathered
	SANDSTONE: Very fine to fine grained, pinkish, weathered
	SANDSTONE: Very fine to fine grained, light, yellowish, brown, weathered
	SILTSTONE: Light, yellowish, brown, weathered
	SANDSTONE: Very fine to fine grained, creamy, weathered
	SILTSTONE: Creamy, weathered
	SANDSTONE: Very fine to fine grained, light, pinkish, cream, weathered
Rewan Formation (Triassic)	SILTSTONE: Light, yellowish, brown, weathered
	SILTSTONE: Pinkish, weathered
	SANDSTONE: Fine to medium grained, light, brownish, buff, weathered
	SILTSTONE: Pinkish, weathered
	CLAYSTONE: Dark, purplish, brown, BASE OF WEATHERING.
	SILTSTONE: Dark, pink, fresh
	SANDSTONE: Very fine to fine grained, brown, fresh
	CLAYSTONE: Greenish, grey, fresh
	SILTSTONE: Greenish, grey, fresh
	SANDSTONE: Very fine to fine grained, grey, fresh
	SILTSTONE: Greenish, grey
	SILTSTONE: Dark, purplish, grey
	SANDSTONE: Very fine to fine grained, greenish, grey
	SILTSTONE: Greenish, grey, sandy in part
	SANDSTONE: Very fine to fine grained, grey, silty near base of unit
	SANDSTONE: Very fine to fine grained, greenish, grey



Bore Description

Protective lockable steel collar
PVC Stick up: 0.65 m

165 mm PCD bit: 0 m to 101 m

Bentonite grout: 0 m to 87 m

50 mm, PN18 uPVC, blank casing: 0.65 mAGL to 95 m

SWL at 62.19 mBGL on 3rd Jul 2013

Bentonite seal: 87 m to 89 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 89 m to 101 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 95 m to 101 m
slots opened to 1 mm every metre for stygofauna sampling

BOC: 101 m

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BOREHOLE LOG

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MB13

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **25-Mar-13**
LOGGED BY: **H.Donovan**

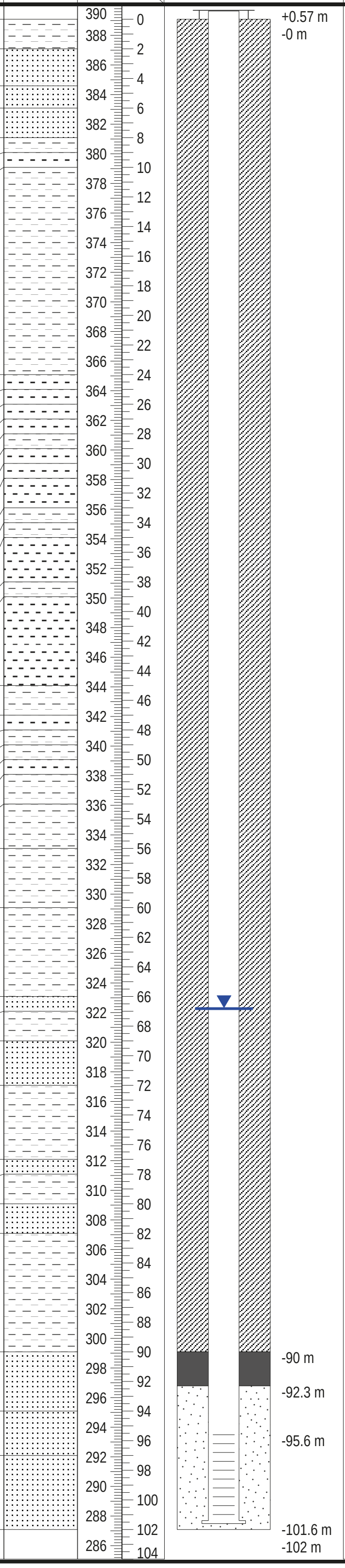
DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **J.Freeman (3335)**
DRILLING METHOD: **Air Rotary**

SITE ID: **K21.5**
EASTING: **408638.04 mE**
NORTHING: **7594222.58 mN**
DATUM: **GDA94 (z55)**
RL: **389.09 mAHD**
TD: **102 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	SILTSTONE: Medium, brownish, orange, sandy
	SANDSTONE: Fine grained, light to medium, brownish, orange
	SANDSTONE: Fine grained, light, yellow
	SANDSTONE: Fine grained, medium, yellow
	SILTSTONE: Light, pinkish, cream, sandy
	CLAYSTONE: Dark, red
	SILTSTONE: Light, pinkish, cream, occasional, sandy, clayey
	CLAYSTONE: Medium, yellowish, orange
	CLAYSTONE: Medium, brownish, red, occasional, silty
	CLAYSTONE: Medium, purplish, red, occasional, silty
	CLAYSTONE: Dark, red, occasional, silty
	SILTSTONE: Medium, purplish, red, clayey
	CLAYSTONE: Dark, red
	CLAYSTONE: Mottled, brownish, red, silty
	CLAYSTONE: Dark, red
	SILTSTONE: Light, yellowish, brown, occasional, clayey
	SILTSTONE: Light, creamy, grey
	CLAYSTONE: Dark, reddish, brown, silty
	SILTSTONE: Light, grey
	CLAYSTONE: Medium, brown, occasional, silty
	SILTSTONE: Medium, grey
	CLAYSTONE: Medium, brown
	SILTSTONE: Medium, brownish, green, clayey
	SILTSTONE: Light to medium, grey, clayey
	CLAYSTONE: Medium, brown
	SILTSTONE: Medium, grey
	SILTSTONE: Medium, brown
	SILTSTONE: Light, grey
	SILTSTONE: Medium to dark, grey
	SANDSTONE: Fine grained, medium, grey
	SILTSTONE: Medium, grey
	SANDSTONE: Fine grained, medium, grey
	SILTSTONE: Light, grey
	SANDSTONE: Fine grained, medium, grey
	SILTSTONE: Light, grey
	SANDSTONE: Fine grained, light, grey
	SILTSTONE: Medium, grey, clayey, near top of unit
	SANDSTONE: Fine grained, medium, brownish, grey
	SANDSTONE: Fine grained, light, grey, silty
	SANDSTONE: Fine grained, medium, brownish, grey, silty

Graphic Log | R.L. (mAHD) | Depth (mBGL) | Bore Construction



Bore Description

Protective lockable steel collar
PVC Stick up: 0.57 m

152 mm PCD bit: 0 m to 102 m

Bentonite grout: 0 m to 90 m

50 mm, PN18 uPVC, blank casing: 0.57 mAGL to 95.6 m

SWL at 66.82 mBGL on 30th May 2013

Bentonite seal: 90 m to 92.3 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 92.3 m to 102 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 95.6 m to 101.6 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 101.6 m

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BOREHOLE LOG

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MB14

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **23-Mar-13**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **J.Freeman (3335)**
DRILLING METHOD: **Air Rotary**

SITE ID: **NO26**
EASTING: **407588.75 mE**
NORTHING: **7598323.11 mN**
DATUM: **GDA94 (z55)**
RL: **446.34 mAHD**
TD: **150 mBGL**

COMMENTS:

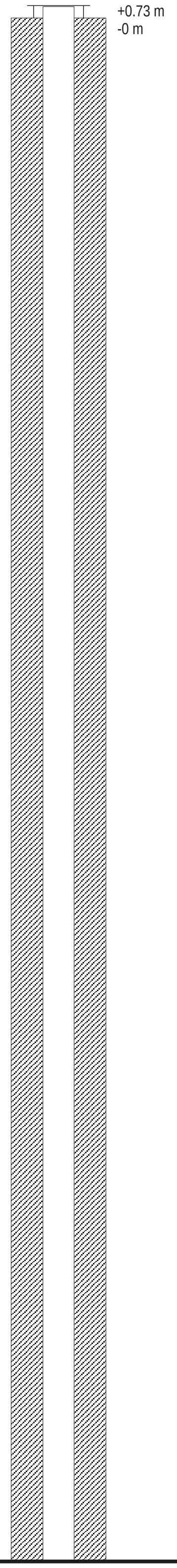
Stratigraphic Interpretation	Soil or Rock Field Material Description	Bore Description
Tertiary sediments	SOIL: Medium, brownish, red, sandy, clayey, extremely weathered	Protective lockable steel collar PVC Stick up: 0.73 m 152 mm PCD bit: 0 m to 150 m
	CLAYSTONE: Medium, reddish, brown, sandy, extremely weathered	Bentonite grout: 0 m to 136 m
Rewan Formation (Triassic)	SANDSTONE: Medium grained, medium, cream, distinctly weathered	
	CLAYSTONE: Light, cream, distinctly weathered	
	SANDSTONE: Fine grained, medium, cream, distinctly weathered	
	CLAYSTONE: Light, cream, distinctly weathered	50 mm, PN18 uPVC, blank casing: 0.73 mAGL to 141 m
	SANDSTONE: Medium grained, medium, cream, distinctly weathered	
	CLAYSTONE: Light, cream, distinctly weathered	
	SILTSTONE: Medium, pink, distinctly weathered	
	SANDSTONE: Medium grained, medium, orange, distinctly weathered	
	CLAYSTONE: White, distinctly weathered	
	SANDSTONE: Fine grained, medium, pinkish, orange, distinctly weathered	
	SANDSTONE: Medium grained, medium, cream, distinctly weathered	
	CLAYSTONE: Medium, cream, distinctly weathered	
	CLAYSTONE: Medium, orangey, brown, distinctly weathered	
	CLAYSTONE: Medium, pink, distinctly weathered	
	CLAYSTONE: Medium, creamy, pink, sandy, distinctly weathered	
	SANDSTONE: Fine grained, medium, orangey, yellow, distinctly weathered	
	CLAYSTONE: Medium, reddish, orange, distinctly weathered	
	CLAYSTONE: Medium, pinkish, distinctly weathered	
	CLAYSTONE: Medium, reddish, orange, distinctly weathered	
	CLAYSTONE: Medium, pinkish, distinctly weathered	
	CLAYSTONE: Medium, reddish, orange, distinctly weathered	
	CLAYSTONE: Medium, pinkish, distinctly weathered	
	CLAYSTONE: Medium, yellowish, cream, distinctly weathered	
	CLAYSTONE: Medium, pinkish, cream, distinctly weathered	
	SILTSTONE: Medium, creamy, distinctly weathered	
	SILTSTONE: Medium, pinkish, cream, distinctly weathered	
	SANDSTONE: Medium, yellowish, cream, distinctly weathered	
	CLAYSTONE: Medium, pinkish, distinctly weathered	
	SANDSTONE: Fine grained, medium, purplish, brown, distinctly	
	SANDSTONE: Fine grained, medium, yellowish, cream, distinctly weathered	

Graphic Log

R.L. (mAHD): 447 445 443 441 439 437 435 433 431 429 427 425 423 421 419 417 415 413 411 409 407 405 403 401 399 397 395 393 391 389 387 385 383 381 379 377 375 373

Depth (mBGL): 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74

Bore Construction



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BOREHOLE LOG

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MB14

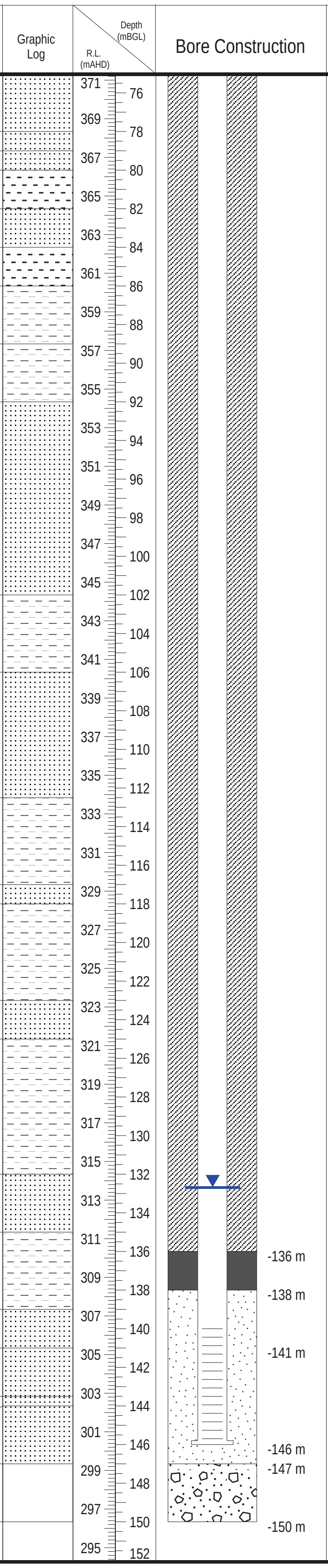
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **23-Mar-13**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **J.Freeman (3335)**
DRILLING METHOD: **Air Rotary**

SITE ID: **NO26**
EASTING: **407588.75 mE**
NORTHING: **7598323.11 mN**
DATUM: **GDA94 (z55)**
RL: **446.34 mAHD**
TD: **150 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	SANDSTONE: Fine grained, medium, yellowish, cream, distinctly weathered
	SANDSTONE: Fine grained, medium, cream, clay, distinctly weathered
	SANDSTONE: Fine grained, medium, brown, distinctly weathered
	CLAYSTONE: Medium, creamy, white, distinctly weathered
	SANDSTONE: Fine grained, medium, creamy, white, clayey, distinctly weathered
	CLAYSTONE: Medium, creamy, grey, distinctly weathered
	SILTSTONE: Medium, grey, d
	SILTSTONE: Medium, greyish, cream, distinctly weathered
	SANDSTONE: Fine to medium grained, medium, yellowish, brown, distinctly weathered
	SILTSTONE: Medium, greyish, yellow, slightly weathered
	SANDSTONE: Fine to medium grained, medium, yellowish, brown, distinctly weathered. BASE OF WEATHERING.
	SILTSTONE: Medium, grey, fresh.
	SANDSTONE: Fine grained, medium, grey
	SILTSTONE: Medium, grey
	SANDSTONE: Fine grained, medium, grey
	SILTSTONE: Medium, grey
	SANDSTONE: Fine grained, medium, grey, fresh
	SILTSTONE: Medium, grey
	SANDSTONE: Fine grained, medium, grey
	SANDSTONE: Fine grained, medium, brownish, grey
	SANDSTONE: Fine grained, medium, grey
	SANDSTONE: Fine grained, medium, grey
	NOT SAMPLED: No return



Bore Description

SWL at 132.69 mBGL on 4th Jun 2013

Bentonite seal: 136 m to 138 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 138 m to 147 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 141 m to 146 m
slots opened to 1 mm every metre for stygofauna sampling
BOC: 146 m
Hole collapse: 147 m to 150 m

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BOREHOLE LOG

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MB15

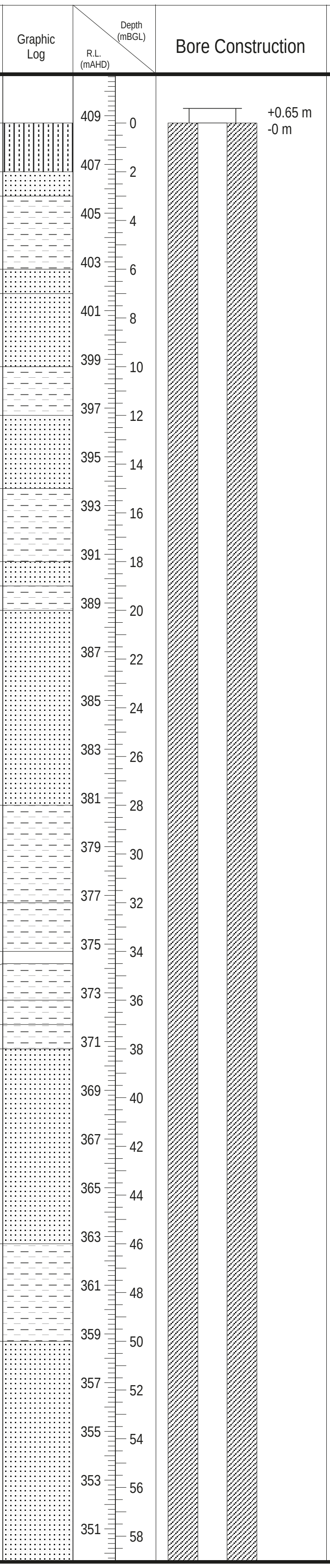
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **5-Jun-13**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **J.Freeman (3335)**
DRILLING METHOD: **Mud Rotary**

SITE ID: **ST28.5**
EASTING: **409522.37 mE**
NORTHING: **7602328.37 mN**
DATUM: **GDA94 (z55)**
RL: **408.7 mAHD**
TD: **119.4 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SOIL: Dark, brown, weathered
	SANDSTONE: Fine grained, dark, brown, weathered
	SILTSTONE: Light, yellowish, brown, weathered
	SANDSTONE: Pink, weathered
	SANDSTONE: Very fine to fine grained, brown, weathered
	SILTSTONE: Pinkish, weathered
	SANDSTONE: Very fine to fine grained, light, yellowish, brown, weathered
	SILTSTONE: Light, pinkish, brown, weathered
	SANDSTONE: Fine grained, creamy, weathered
	SILTSTONE: Mottled, purplish, brown, weathered
	SANDSTONE: Mottled, pinkish, brown, minor silty bands near middle of unit, weathered
	SILTSTONE: Dark, reddish, brown, clayey in part, weathered
Clematis Sandstone (Triassic)	SILTSTONE: Light, brownish, pink, weathered
	SIDERITE: Dark, brown, weathered
	SILTSTONE: Light, brown, weathered
	SILTSTONE: Purplish, weathered
	SILTSTONE: Light, creamy, brown, weathered
	SANDSTONE: Very fine to fine grained, light, pinkish, brown, silty, in part, weathered
	SILTSTONE: Light, purplish, brown, weathered



Bore Description

Protective lockable steel collar
PVC Stick up: 0.65m

165 mm PCD bit: 0 m to 119.4 m

Bentonite grout: 0 m to 101.4 m

50 mm, PN18 uPVC, blank casing: 0.65 mAGL to 109.4 m

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BOREHOLE LOG

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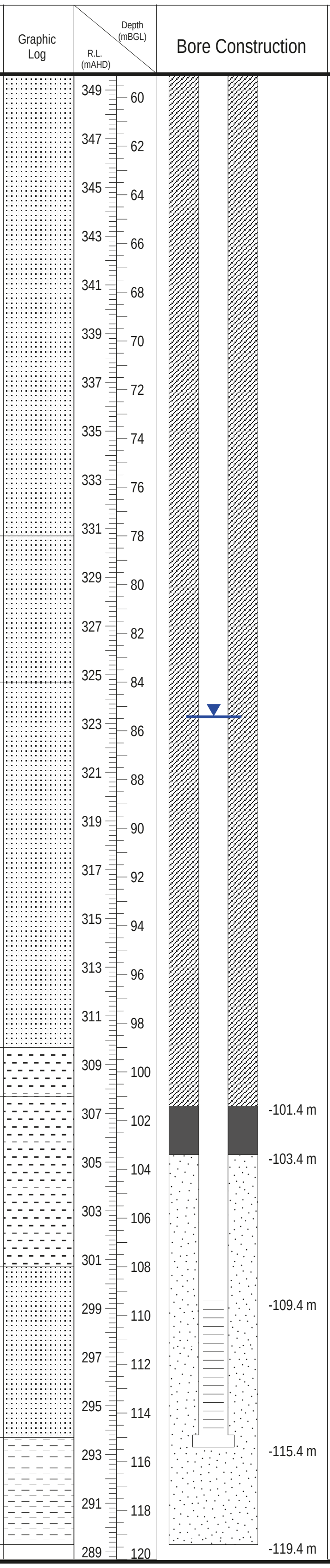
MB15

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **5-Jun-13**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **J.Freeman (3335)**
DRILLING METHOD: **Mud Rotary**

SITE ID: **ST28.5**
EASTING: **409522.37 mE**
NORTHING: **7602328.37 mN**
DATUM: **GDA94 (z55)**
RL: **408.7 mAHD**
TD: **119.4 mBGL**

COMMENTS:



Stratigraphic Interpretation	Soil or Rock Field Material Description	Bore Description
Clematis Sandstone (Triassic)	SANDSTONE: Very fine to fine grained, light, yellowish, brown, rare silty phases near middle of unit, weathered	
	SANDSTONE: Very fine to fine grained, pinkish, cream, weathered	
	SANDSTONE: Fine grained, light, brown, weathered	SWL at 85.42 mBGL on 5th Jul 2013
	CLAYSTONE: Light, yellowish, brown, slightly weathered. BASE OF WEATHERING.	
Rewan Formation (Triassic)	CLAYSTONE: Grey, fresh	Bentonite seal: 101.4 m to 103.4 m 3 mm to 6 mm washed, rounded, quartz gravel pack: 103.4 m to 119.4 m
	SANDSTONE: Very fine to fine grained, grey, silty near top of unit near base of unit, fresh	50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 109.4 m to 115.4 m slots opened to 1 mm every metre for stygofauna sampling
	SILTSTONE: Grey, fresh	BOC: 115.4 m

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MB16

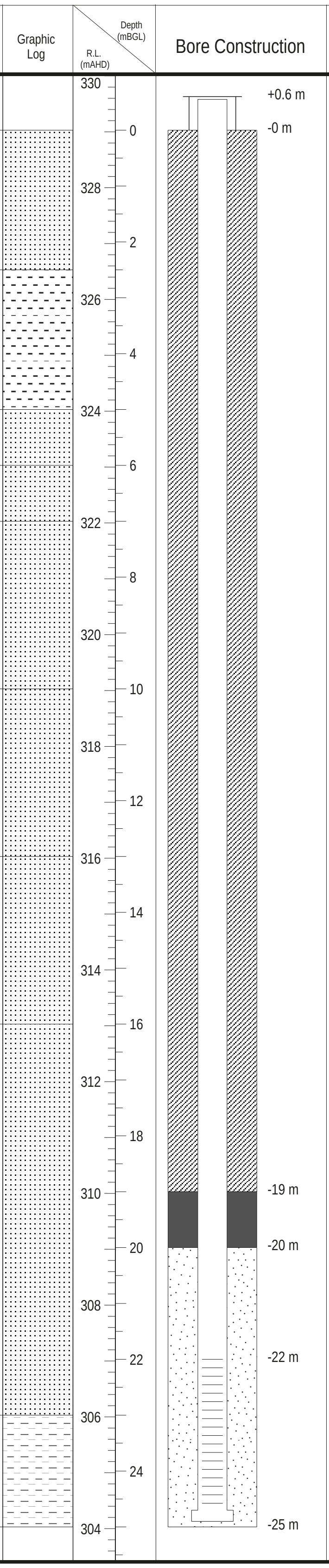
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **8-Jun-13**
LOGGED BY: **B.Walker**

DRILLING COMPANY: **Eastern Drilling**
LICENCED DRILLER: **C.Lappin (3363)**
DRILLING METHOD: **Air Rotary**

SITE ID: **DE6**
EASTING: **417115.19 mE**
NORTHING: **7585134.44 mN**
DATUM: **GDA94 (z55)**
RL: **329.03 mAHD**
TD: **25 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SANDSTONE: Fine grained, mottled, brown, weathered
	CLAYSTONE: Dark, brown, weathered
	SANDSTONE: Very fine to fine grained, creamy, weathered
	SANDSTONE: Coarse grained, light, brown, weathered
	SANDSTONE: Very fine to fine grained, brown, silty in part, weathered
	SANDSTONE: Fine to coarse grained, light, creamy, brown, weathered
	SANDSTONE: Fine to coarse grained, mottled, brown, conglomeratic in part, weathered
	SANDSTONE: Fine grained, light, whitish, grey, silty, weathered
	SILTSTONE: Mottled, reddish, white, lateritic, clayey, weathered



Bore Description

Protective lockable steel collar

PVC Stick up: 0.6 m

152 mm PCD bit: 0 m to 25 m

Bentonite grout: 0 m to 19 m

50 mm, PN18 uPVC, blank casing: 0.6 mAGL to 22 m

bore dry at the time of drilling, still dry on the 3rd Jul 2013

Bentonite seal: 19 m to 20 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 20 m to 25 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 22 m to 25 m
slots opened to 1 mm every metre for stygofauna sampling

BOC: 25 m

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BOREHOLE LOG

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MB17

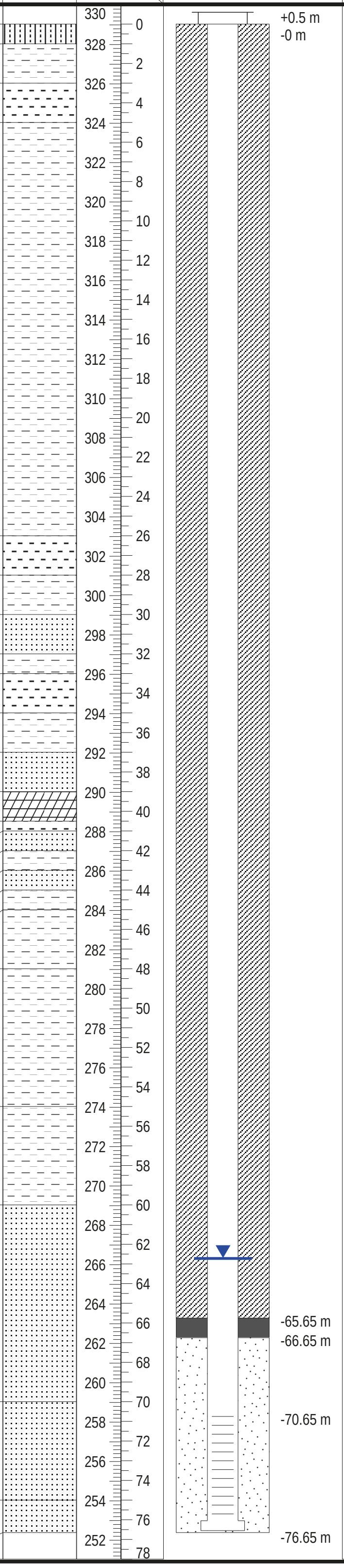
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **6-Jun-13**
LOGGED BY: **B.Walker**

DRILLING COMPANY: **Eastern Drilling**
LICENCED DRILLER: **C.Lappin (3363)**
DRILLING METHOD: **Air Rotary**

SITE ID: **F7**
EASTING: **417117.99 mE**
NORTHING: **7585136.77 mN**
DATUM: **GDA94 (z55)**
RL: **329.04 mAHD**
TD: **76.65 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SOIL: Brown, weathered
	SILTSTONE: Brown, weathered
	CLAYSTONE: Dark, brown, weathered
	SILTSTONE: Mottled, brown, clayey in part, weathered
	CLAYSTONE: Weathered
	SILTSTONE: Whitish, weathered
	SANDSTONE: Very fine to fine grained, creamy, weathered
	SILTSTONE: Light, brown, weathered
	CLAYSTONE: Whitish, weathered
	SILTSTONE: Buff, weathered
	SANDSTONE: Very fine to fine grained, creamy, white, weathered
	SILCRETE: Greyish, white, weathered
	CLAYSTONE: Greyish, weathered
	SANDSTONE: Very fine to fine grained, creamy, weathered
	SILTSTONE: Whitish, weathered
	SANDSTONE: Very fine to fine grained, creamy, weathered
	SILTSTONE: Whitish, weathered
	SILTSTONE: Mottled, pinkish, purple, weathered
	SILTSTONE: Mottled, brown, clayey in part, weathered
	SILTSTONE: Pinkish, weathered
	SANDSTONE: Very fine to fine grained, light, pinkish, brown, weathered
	SANDSTONE: Fine to medium grained, mottled, creamy, brown, weathered
	SANDSTONE: Medium to coarse grained, brown, conglomeratic near top of unit, weathered



Bore Description

Protective lockable steel collar
PVC Stick up: 0.5 m

165 mm PCD bit: 0 m to 76.65 m

Bentonite grout: 0 m to 65.65 m

50 mm, PN18 uPVC, blank casing: 0.5 mAGL to 70.65 m

SWL at 62.72 mBGL on 3rd Jul 2013

Bentonite seal: 65.65 m to 66.65 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 66.65 m to 76.65 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 70.65 m to 76.65 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 76.65 m

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BOREHOLE LOG

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MB18

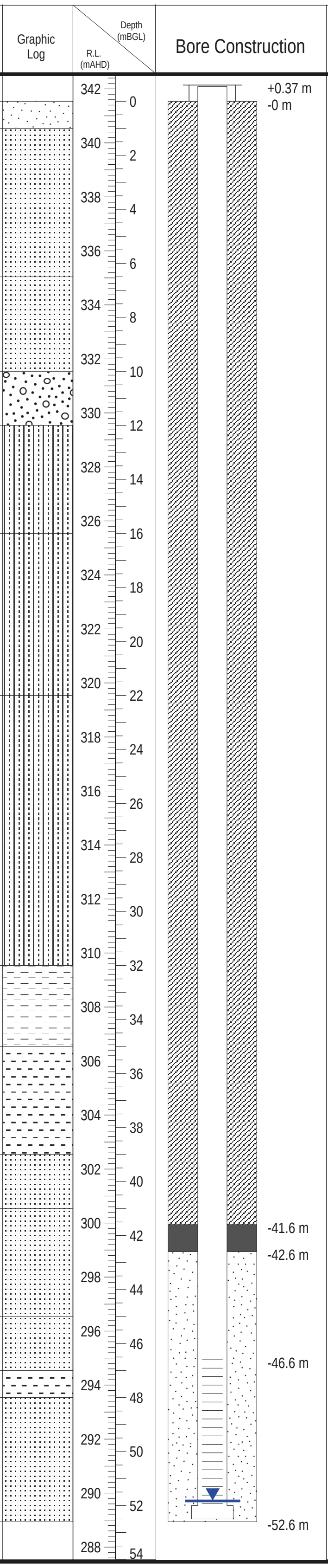
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **13-Dec-12**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **M.Rhook (3342)**
DRILLING METHOD: **Air Rotary**

SITE ID: **BC7.5**
EASTING: **414441.65 mE**
NORTHING: **7583778.25 mN**
DATUM: **GDA94 (z55)**
RL: **341.54 mAHD**
TD: **52.6 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SAND: Very fine grained, weathered to soil
	SANDSTONE: Fine to medium grained, red/orange, highly weathered
	SANDSTONE: Fine grained, red/orange, highly weathered
	GRAVEL CONGLOMERATE: Pink/brown, granule sized, highly weathered, abundant quartz
	LATERITE: Pink, buff, coarse grained, sandy, highly weathered
	LATERITE: Mottled, pink, silty, highly weathered
	LATERITE: Dark pink, clayey, highly weathered
	SILTSTONE: Yellow/pink, highly weathered
	CLAYSTONE: Dark pink, highly weathered
	SANDSTONE: Very fine to fine grained, pink/yellow, moderately weathered
	SANDSTONE: Fine to medium grained, pink, moderately weathered
	SANDSTONE: Very fine to fine grained, pink/yellow, moderately weathered
	CLAYSTONE: Mottled pink, moderately weathered
	SANDSTONE: Very fine to fine grained, light, buff, moderately weathered



Bore Description

Protective lockable steel collar
PVC Stick up: 0.37 m

165 mm PCD bit: 0 m to 52.6 m

Bentonite grout: 0 m to 41.6 m

50 mm, PN18 uPVC, blank casing: 0.37 mAGL to 46.6 m

Bentonite seal: 41.6 m to 42.6 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 42.6 m to 52.6 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 46.6 m to 52.6 m slots opened to 1 mm every metre for stygofauna sampling

bore dry at the time of drilling

SWL at 51.83 mBGL on 15th Dec 2013

BOC: 52.6 m

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MB19

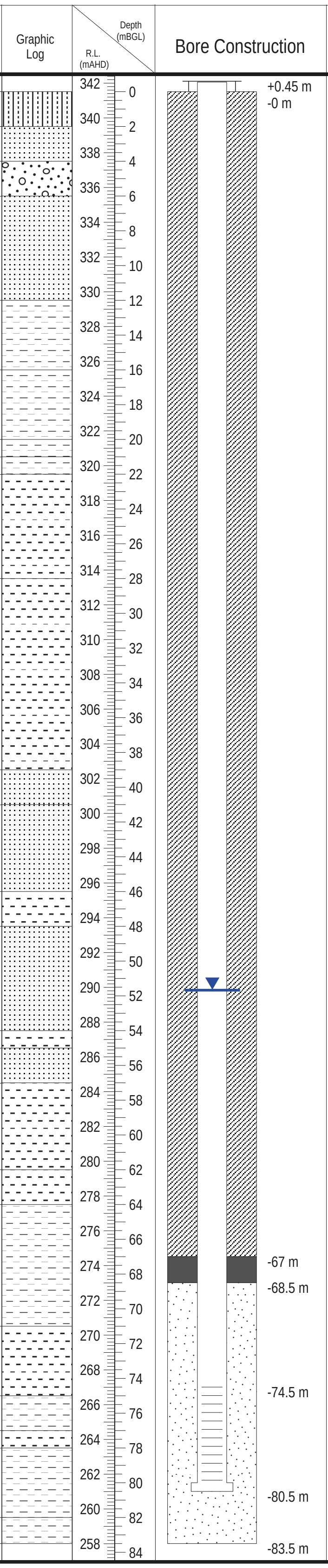
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **13-Dec-12**
LOGGED BY: **H.Donovan**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **M.Rhook (3342)**
DRILLING METHOD: **Air Rotary**

SITE ID: **BC7.5**
EASTING: **414445.77 mE**
NORTHING: **7583780.44 mN**
DATUM: **GDA94 (z55)**
RL: **341.51 mAHD**
TD: **83.5 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SOIL: Red/orange, residual soil
	SANDSTONE: Dark red/brown, moderately weathered
	GRAVEL CONGLOMERATE: Red/orange, ferruginous, ferricrete, moderately weathered
	SANDSTONE: Medium grained, red/orange, quartzose fragments, gravelly, moderately weathered
	SILTSTONE: Red/pink, moderately weathered
	SILTSTONE: Pink/red, moderately weathered
	SILTSTONE: Orange, moderately weathered
	SILTSTONE: Cream pink, clayey, moderately weathered
	CLAYSTONE: Pink/red, moderately weathered
	CLAYSTONE: Light pink/yellow, moderately weathered
	SANDSTONE: Very fine grained, light yellow/orange, moderately weathered
	SANDSTONE: Very fine grained, light yellow/pink, silty in parts, clayey towards base of unit, moderately weathered
	CLAYSTONE: Red/brown, moderately weathered
	SANDSTONE: Very fine grained, light brown, moderately weathered
	CLAYSTONE: Yellow, moderately weathered
	SANDSTONE: Very fine grained, light creamy pink, moderately weathered
Rewan Formation (Triassic)	CLAYSTONE: Dark brown/red, moderately weathered
	CLAYSTONE: Yellow, moderately weathered
	SILTSTONE: Red/brown, moderately weathered
	CLAYSTONE: Dark brown/red, moderately weathered
	SILTSTONE: Green/red, moderately weathered
	CLAYSTONE: Pink/red, moderately weathered
	SILTSTONE: Green/purple, fresh
	SILTSTONE: Purple



Bore Description

Protective lockable steel collar
PVC Stick up: 0.45 m

165 mm PCD bit: 0 m to 83.5 m

Bentonite grout: 0 m to 67 m

50 mm, PN18 uPVC, blank casing: 0.45 mAGL to 74.5 m

bore dry at the time of drilling
SWL at 51.67 mBGL on 15th Dec 2013

Bentonite seal: 67 m to 68.5 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 68.5 m to 80.5 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 74.5 m to 80.5 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 80.5 m

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BOREHOLE LOG

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MB20

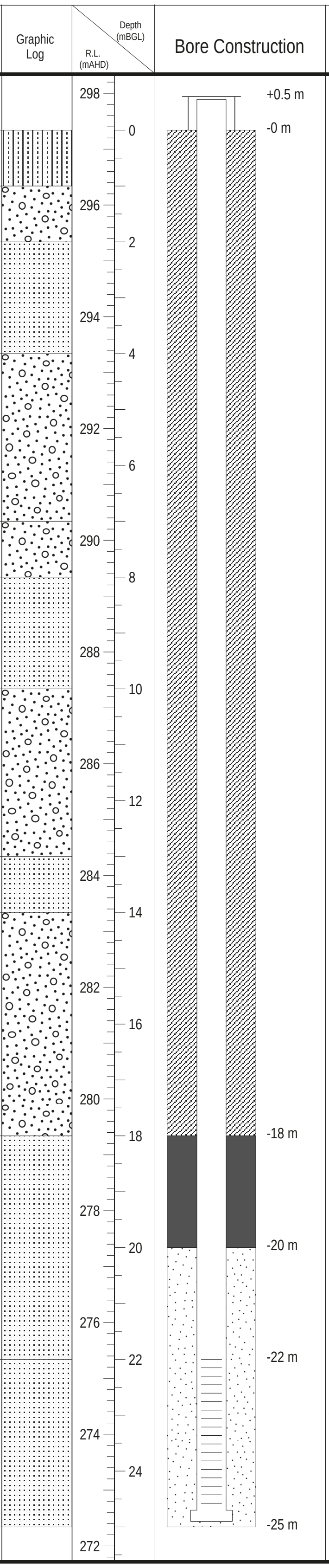
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **31-May-13**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **S.Colles (3313)**
DRILLING METHOD: **Air Rotary**

SITE ID: **M9**
EASTING: **420926.08 mE**
NORTHING: **7589917.13 mN**
DATUM: **GDA94 (z55)**
RL: **297.34 mAHD**
TD: **25 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SOIL: Brown, sandy, extremely weathered
	GRAVEL CONGLOMERATE: Light, brown, quartzose, iron stained, extremely weathered
	SANDSTONE: Medium to coarse grained, orange, quartzose, extremely weathered
	GRAVEL CONGLOMERATE: Light, brownish, orange, quartzose, extremely weathered
	GRAVEL CONGLOMERATE: Light, whitish, pink, distinctly weathered
	SANDSTONE: Fine grained, light, whitish, pink, silty, in part, distinctly weathered
	GRAVEL CONGLOMERATE: Medium grained, light, orangey, brown, quartzose, distinctly weathered
	SANDSTONE: Fine grained, light, red, quartzose, distinctly weathered
	GRAVEL CONGLOMERATE: Mottled, grey, distinctly weathered
	SANDSTONE: Fine to medium grained, light, brown, pebbles, In part, quartzose, distinctly weathered
	SANDSTONE: Fine grained, red, distinctly weathered



Bore Description

Protective lockable steel collar

PVC Stick up: 0.5 m (estimate)

165 mm PCD bit: 0 m to 25 m

Bentonite grout: 0 m to 18 m

50 mm, PN18 uPVC, blank casing: 0.5 mAGL to 22 m

Bentonite seal: 18 m to 20 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 20 m to 25 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 22 m to 25 m
slots opened to 1 mm every metre for stygofauna sampling
BOC: 25 m

bore dry at the time of drilling

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BOREHOLE LOG

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MB21

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **27-Aug-13**
LOGGED BY: **MBGS Geologist**

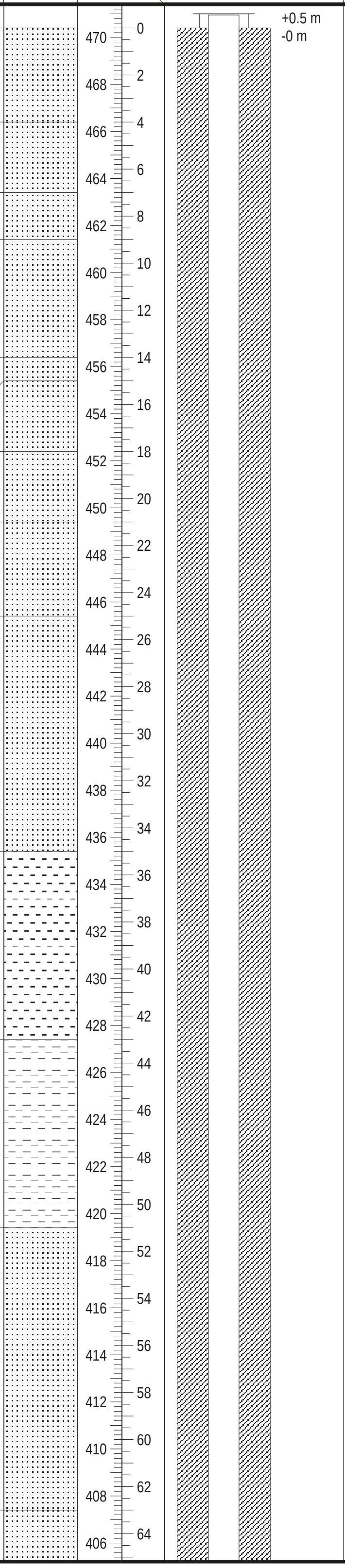
DRILLING COMPANY: **Eastern Drilling**
LICENCED DRILLER: **C.Lappin (3363)**
DRILLING METHOD: **Air Rotary**

SITE ID: **I21**
EASTING: **407808.81 mE**
NORTHING: **7592771.38 mN**
DATUM: **GDA94 (z55)**
RL: **470.4 mAHD**
TD: **130.5 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SANDSTONE: Very fine grained, light, yellowish, orange, quartzose.
	SANDSTONE (80%) / SILTSTONE (20%): Very fine grained, light, purplish, red.
	SANDSTONE: Very fine grained, light, yellow, quartzose.
	SANDSTONE: Very fine grained, light, orangy, yellow, quartzose, minor, micaceous.
	SANDSTONE: Very fine to fine grained, light, whitish, yellow, quartzose, siltstone, throughout.
	SANDSTONE: Very fine grained, light, orangy, yellow, siltstone
	SANDSTONE: Fine grained, light, whitish, yellow, quartzose.
	SANDSTONE: Very fine to fine grained, dark, purplish, red, siltstone
	SANDSTONE: Very fine grained, light, orangy, yellow, siltstone, claystone.
	CLAYSTONE: Light, purplish, red, sandstone.
	SILTSTONE (50%) / SILTSTONE (50%): Mottled, purplish, yellow. Very fine grained.
	SANDSTONE: Very fine grained, dark, yellowish, orange, quartzose.

Graphic Log | R.L. (mAHD) | Depth (mBGL) | Bore Construction



Bore Description

Protective lockable steel collar
PVC Stick up: 0.5 m (estimate)

165 mm PCD bit: 0 m to 130.5 m

Bentonite grout: 0 m to 119.5 m

50 mm, PN18 uPVC, blank casing: 0.5 mAGL to 124.5 m

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BOREHOLE LOG

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MB21

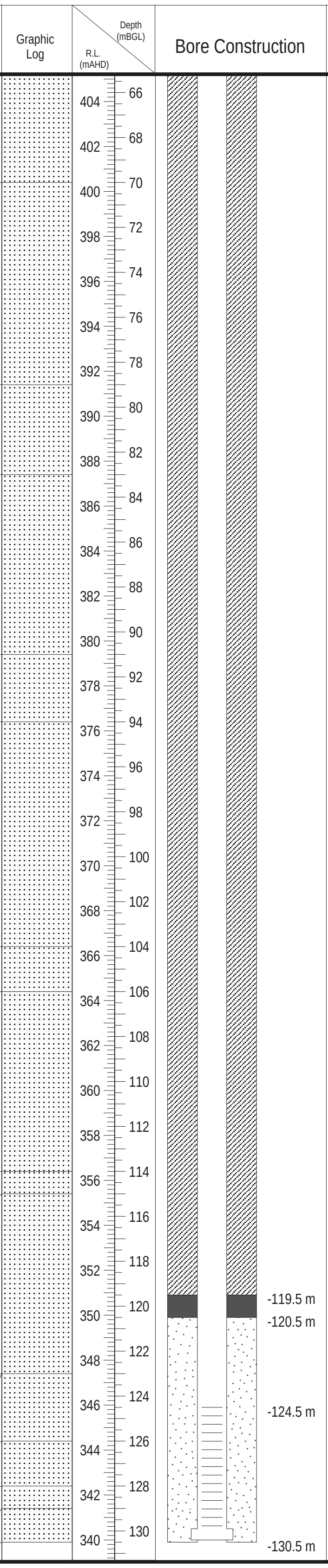
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **27-Aug-13**
LOGGED BY: **MBGS Geologist**

DRILLING COMPANY: **Eastern Drilling**
LICENCED DRILLER: **C.Lappin (3363)**
DRILLING METHOD: **Air Rotary**

SITE ID: **I21**
EASTING: **407808.81 mE**
NORTHING: **7592771.38 mN**
DATUM: **GDA94 (z55)**
RL: **470.4 mAHD**
TD: **130.5 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SANDSTONE: Very fine grained, mottled, purplish, brown, siltstone, throughout, quartzose, fragments.
	SANDSTONE: Very fine grained, dark, yellowish, orange, quartzose.
	SANDSTONE: Very fine grained, light, pinkish, grey, siltstone, in part, distinctly weathered.
	SANDSTONE: Very fine grained, light, orangy, grey, siltstone, in part, distinctly weathered.
	SANDSTONE: Very fine grained, medium to dark, reddish, grey, distinctly weathered.
	SANDSTONE: Very fine grained, medium to dark, reddish, grey, distinctly weathered.
	SANDSTONE: Very fine grained, medium to dark, reddish, grey, distinctly weathered.
	SANDSTONE: Very fine grained, light, orangy, grey, siltstone, in part, slightly weathered.
	SANDSTONE: Very fine grained, medium, orangy, grey, distinctly weathered.
	SANDSTONE: Very fine grained, light, orangy, grey, siltstone, in part, slightly weathered.
	SANDSTONE: Very fine grained, light, yellowish, grey, distinctly weathered.
	SANDSTONE: Very fine grained, light to medium, pinkish, grey, siltstone, in part, distinctly weathered.
	SANDSTONE: Very fine grained, medium, orangy, grey, distinctly weathered.
	SANDSTONE: Very fine grained, medium, reddish, grey, distinctly weathered.
	SANDSTONE: Very fine grained, light, orangy, grey.



Bore Description

bore dry at the time of drilling

Bentonite seal: 119.5 m to 120.5 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 120.5 m to 130.5 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 124.5 m to 130.5 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 130.5 m

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BOREHOLE LOG

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MB22

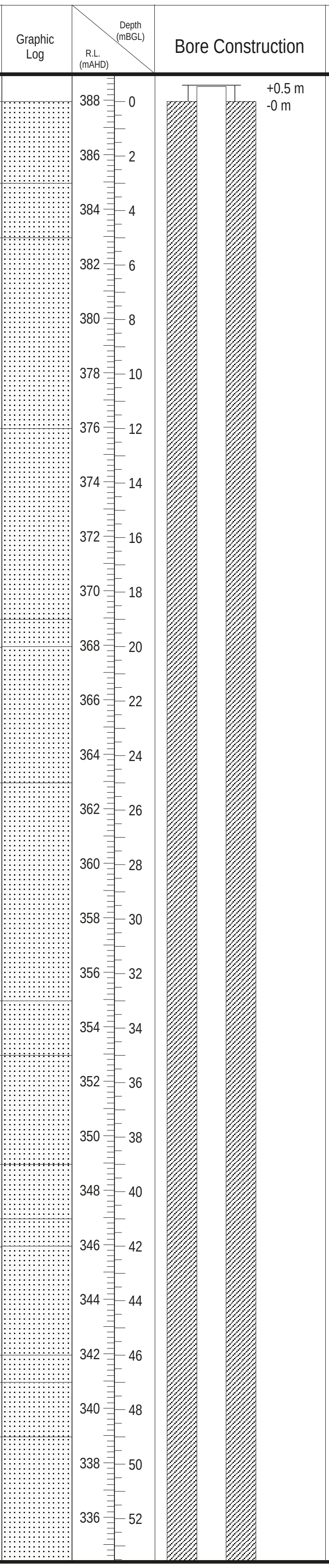
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **29-Sep-13**
LOGGED BY: **A.Tarr**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Air Rotary**

SITE ID: **E15**
EASTING: **409253.62 mE**
NORTHING: **7588045.6 mN**
DATUM: **GDA94 (z55)**
RL: **387.95 mAHD**
TD: **107.5 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SANDSTONE: Very fine to fine grained, mottled, creamy, red, lithic, minor, quartzose, extremely weathered.
	SANDSTONE: Very fine grained, creamy, pink, extremely weathered.
	SANDSTONE: Very fine to fine grained, dark, orangy, red, quartzose, throughout, minor, micaceous, extremely weathered.
	SANDSTONE: Very fine to fine grained, light, pinkish, yellow, quartzose, throughout, extremely weathered.
	SANDSTONE: Fine to medium grained, light, pinkish, yellow, quartzose, extremely weathered.
	SANDSTONE: Very fine to fine grained, light, creamy, yellow, quartzose, extremely weathered.
	SANDSTONE: Very fine grained, light, creamy, yellow, quartzose, fragments, throughout, extremely weathered.
	SANDSTONE: Very fine to fine grained, medium to dark, orangy, brown, quartzose, extremely weathered.
	SANDSTONE: Very fine grained, medium to dark, pinkish, brown, extremely weathered.
	SANDSTONE: Very fine to fine grained, dark, brownish, red, extremely weathered.
	SANDSTONE: Very fine grained, dark, orangy, yellow, extremely weathered.
	SANDSTONE: Very fine grained, light, creamy, yellow, extremely weathered.
	SANDSTONE: Very fine grained, dark, brownish, red.
	SANDSTONE: Very fine grained, light, creamy, pink, extremely weathered.
	SANDSTONE: Very fine grained, dark, brownish, red.



Bore Description

Protective lockable steel collar
PVC Stick up: 0.5 m (estimate)

BOC: 107.5 m

152 mm PCD bit: 0 m to 107.5 m

Bentonite grout: 0 m to 87.5 m

50 mm, PN18 uPVC, blank casing: 0.5 mAGL to 101.5 m

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BOREHOLE LOG

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MB22

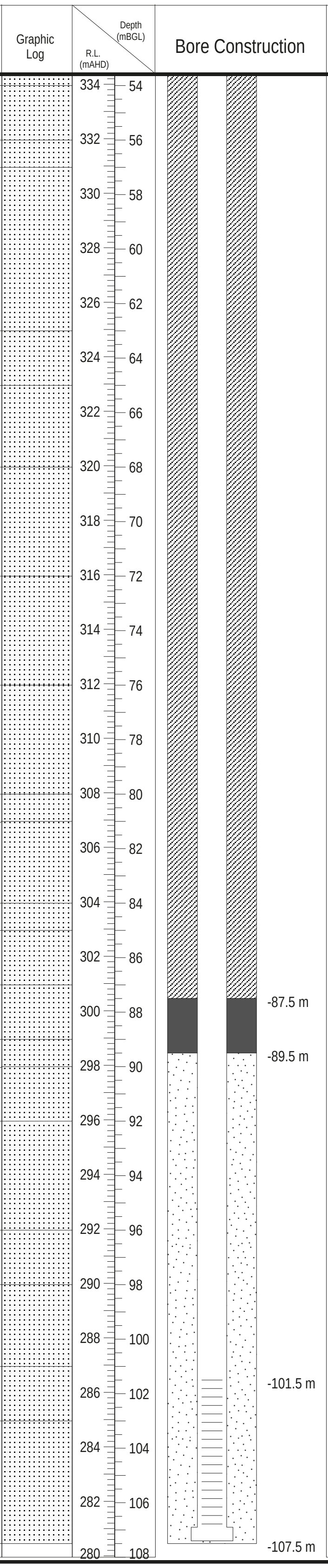
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **29-Sep-13**
LOGGED BY: **A.Tarr**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Air Rotary**

SITE ID: **E15**
EASTING: **409253.62 mE**
NORTHING: **7588045.6 mN**
DATUM: **GDA94 (z55)**
RL: **387.95 mAHD**
TD: **107.5 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SANDSTONE: Very fine grained, medium to dark, yellowish, brown.
	SANDSTONE: Very fine grained, dark, reddish, brown.
	SANDSTONE: Very fine grained, light, creamy, yellow.
	SANDSTONE: Very fine grained, dark, reddish, brown.
	SANDSTONE: Very fine grained, light, pinkish, brown.
	SANDSTONE: Very fine grained, light, orangy, brown, extremely weathered.
	SANDSTONE: Very fine grained, light, orangy, brown, minor, micaceous, extremely weathered.
	SANDSTONE: Very fine grained, light, pinkish, brown, quartzose, fragments, extremely weathered.
	SANDSTONE: Very fine grained, dark, brown, minor, micaceous, extremely weathered.
	SANDSTONE: Very fine grained, light, orangy, yellow, extremely weathered.
	SANDSTONE: Very fine grained, dark, brown, extremely weathered.
	SANDSTONE: Very fine grained, dark, reddish, brown, extremely weathered.
	SANDSTONE: Very fine grained, dark, brown, extremely weathered.
	SANDSTONE: Very fine to fine grained, dark, orangy, yellow, extremely weathered.
	SANDSTONE: Very fine to fine grained, light, brownish, grey, extremely weathered.
	SANDSTONE: Very fine to fine grained, light, brownish, orange, extremely weathered.
	SANDSTONE: Very fine grained, dark, reddish, brown, extremely weathered.
	SANDSTONE: Very fine to fine grained, light, brownish, orange, quartzose, extremely weathered.
	SANDSTONE: Very fine grained, dark, reddish, brown, extremely weathered.
	SANDSTONE: Very fine grained, light, brownish, orange, minor, quartzose.



Bore Description

Bentonite seal: 87.5 m to 89.5 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 89.5 m to 107.5 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 101.5 m to 107.5 m slots opened to 1 mm every metre for stygofauna sampling

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BOREHOLE LOG

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MB23

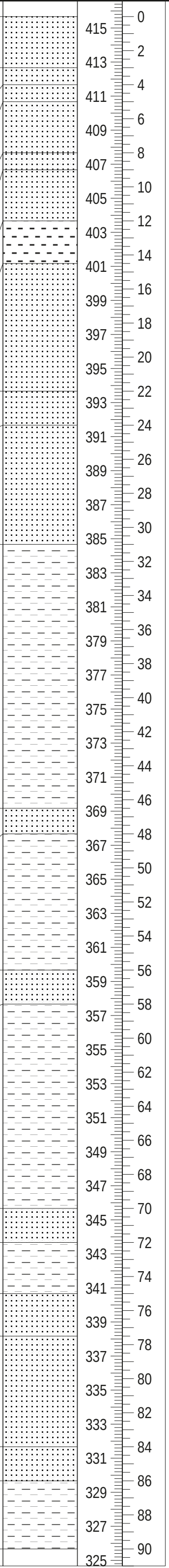
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **13-Sep-13**
LOGGED BY: **T. Womack**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Air Rotary**

SITE ID: **M22**
EASTING: **410019.27 mE**
NORTHING: **7595391.94 mN**
DATUM: **GDA94 (z55)**
RL: **415.67 mAHD**
TD: **90 mBGL**

COMMENTS: **no construction details from client**

Stratigraphic Interpretation	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
Clematis Sandstone (Triassic)	SANDSTONE: Fine to medium grained, light to medium, creamy, orange, distinctly weathered, low strength rock.				
	SANDSTONE: Very fine grained, light, pinkish, grey, d, low strength rock.				
	SANDSTONE: Very fine grained, medium to dark, reddish, grey, distinctly weathered, very low strength rock				
	SANDSTONE: Very fine grained, medium to dark, pinkish, grey, distinctly weathered, low strength rock.				
	SANDSTONE: Very fine grained, light, grey, slightly weathered, low strength rock.				
	SANDSTONE: Very fine grained, light, pinkish, grey, slightly weathered, low strength rock.				
	CLAYSTONE: Dark, greyish, brown, distinctly weathered, extremely low strength rock.				
	SANDSTONE: Very fine to fine grained, light to medium, yellowish, orange, distinctly weathered, extremely low strength rock.				
	SANDSTONE: Very fine grained, light, orangy, grey, slightly weathered, very low strength rock.				
	SANDSTONE: Very fine grained, light to medium, greyish, orange, distinctly weathered, very low strength rock				
Rewan Formation (Triassic)	SILTSTONE: Greyish, slightly weathered, very low strength rock.				
	SANDSTONE: Very fine grained, medium to dark, orange, siltstone, in part, distinctly weathered, very low strength rock.				
	SILTSTONE: Medium, grey, distinctly weathered, extremely low strength rock.				
	SANDSTONE: Very fine to fine grained, light to medium, greyish, orange, distinctly weathered, extremely low strength rock.				
	SILTSTONE: Medium, grey, sandstone, in part, slightly weathered, extremely low strength rock.				
	SANDSTONE: Fine grained, medium, grey, slightly weathered. Moist				
	SILTSTONE: Medium, grey, sandstone, in part, slightly weathered, very low strength rock.				
	SANDSTONE: Medium, greyish, orange, siltstone, in part, distinctly weathered, very low strength rock.				
	SANDSTONE: Very fine grained, medium, greyish, orange, siltstone, in part, distinctly weathered, very low strength rock.				
	SANDSTONE: Fine grained, medium, grey, fresh. Moist				
	SILTSTONE: Medium, grey, sandstone, in part, low strength rock				



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BOREHOLE LOG

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MB24

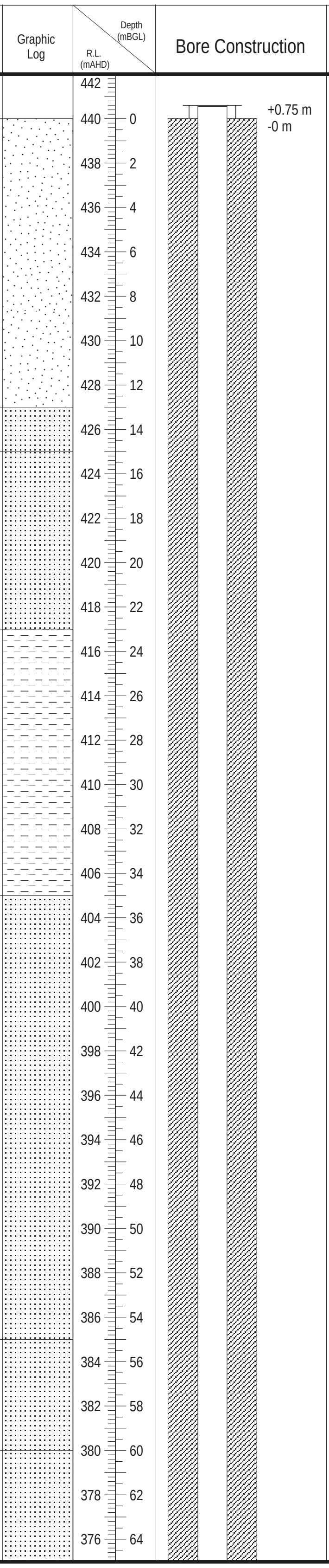
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **25-Jun-13**
LOGGED BY: **H.Donovan**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **J.Freeman (3335)**
DRILLING METHOD: **Air Rotary**

SITE ID: **M24**
EASTING: **408081 mE**
NORTHING: **7596736 mN**
DATUM: **GDA94 (z55)**
RL: **440 mAHD**
TD: **131 mBGL**

COMMENTS: **bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SAND: Light, brownish, pink, extremely weathered
	SANDSTONE: Fine grained, medium, reddish, brown, iron stained, extremely weathered
	SANDSTONE: Very fine to fine grained, medium, reddish, brown, iron stained, silty, in part, extremely weathered
	SILTSTONE: Medium, reddish, brown, iron stained, occasional, sandy, extremely weathered
	SANDSTONE: Very fine to fine grained, medium, reddish, brown, extremely weathered
	SANDSTONE: Very fine to fine grained, light to medium, reddish, brown, occasional, siltstone, bands, distinctly weathered



Bore Description

Protective lockable steel collar
PVC Stick up: 0.75 m

152 mm PCD bit: 0 m to 131 m

Bentonite grout: 0 m to 116 m

50 mm, PN18 uPVC, blank casing: 0.75 mAGL to 124 m

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BOREHOLE LOG

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MB24

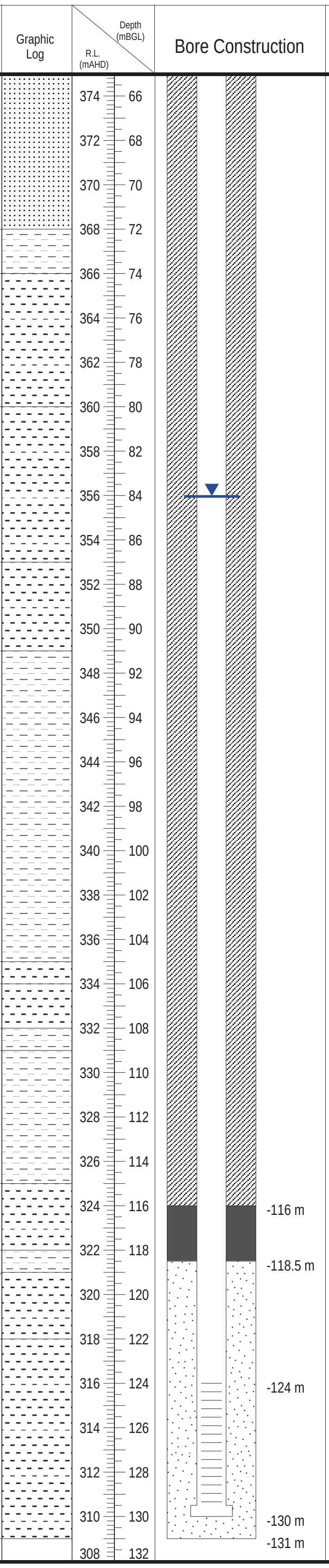
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **25-Jun-13**
LOGGED BY: **H.Donovan**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **J.Freeman (3335)**
DRILLING METHOD: **Air Rotary**

SITE ID: **M24**
EASTING: **408081 mE**
NORTHING: **7596736 mN**
DATUM: **GDA94 (z55)**
RL: **440 mAHD**
TD: **131 mBGL**

COMMENTS: **bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SANDSTONE: Very fine grained, light, creamy, grey, distinctly weathered
Rewan Formation (Triassic)	SILTSTONE: Light, creamy, grey, occasional, sandy, phases, distinctly weathered
	CLAYSTONE: Light, creamy, pink, distinctly weathered
	CLAYSTONE: Light, creamy, pink, distinctly weathered
	CLAYSTONE: Light, yellowish, brown, distinctly weathered
	SILTSTONE: Light to medium, yellowish, brown, distinctly weathered
	CLAYSTONE: Light to medium, creamy, brown, distinctly weathered
	CLAYSTONE: Medium, brownish, red, slightly weathered
	SILTSTONE: Light to medium, creamy, brown, slightly weathered
	SILTSTONE: Medium, pinkish, yellow, slightly weathered
	CLAYSTONE: Light to medium, yellowish, brown, slightly weathered
	SILTSTONE: Medium, yellowish, brown, clayey, in part, slightly weathered
	CLAYSTONE: Light to medium, grey, fresh
	CLAYSTONE: No recovery of chips



Bore Description

SWL at 84.04 mBGL on 15th Jul 2013

Bentonite seal: 116 m to 118.5 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 118.5 m to 130 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 124 m to 130 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 130 m

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BOREHOLE LOG

MB25

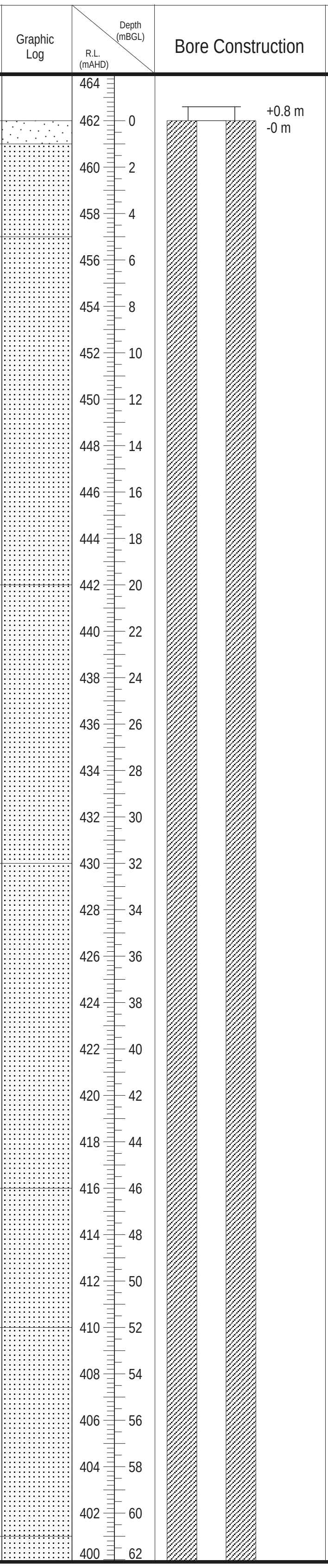
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **6-Jul-13**
LOGGED BY: **J.Souter**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Air Rotary**

SITE ID: **M25**
EASTING: **407410 mE**
NORTHING: **7596980 mN**
DATUM: **GDA94 (z55)**
RL: **462 mAHD**
TD: **125.4 mBGL**

COMMENTS: **redrill; Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SAND: Fine grained, red, extremely weathered
	SANDSTONE: Fine grained, red, extremely weathered
	SANDSTONE: Medium grained, light, brownish, red, distinctly weathered
	SANDSTONE: Coarse grained, light, brownish, red, quartzose, distinctly weathered
	SANDSTONE: Coarse grained, light, reddish, brown,
	SANDSTONE: Coarse grained, light, reddish, brown,
	SANDSTONE: Fine grained, light, pinkish, brown, distinctly weathered
	SANDSTONE: Fine grained, light, yellow, distinctly weathered



Bore Description

Protective lockable steel collar
PVC Stick up: 0.8 m

152 mm PCD bit: 0 m to 125.4 m

Bentonite grout: 0 m to 109.4 m

50 mm, PN18 uPVC, blank casing: 0.8 mAGL to 118.4 m

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BOREHOLE LOG

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MB25

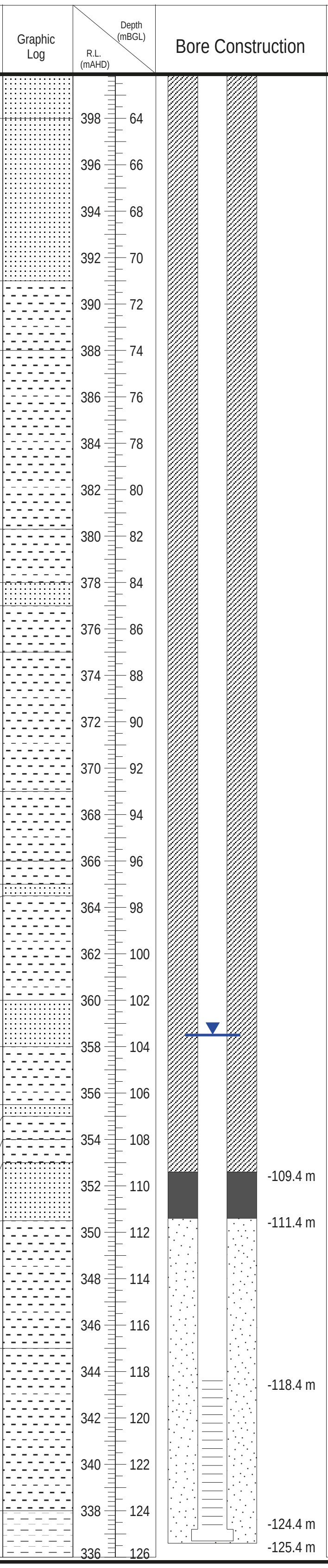
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **6-Jul-13**
LOGGED BY: **J.Souter**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Air Rotary**

SITE ID: **M25**
EASTING: **407410 mE**
NORTHING: **7596980 mN**
DATUM: **GDA94 (z55)**
RL: **462 mAHD**
TD: **125.4 mBGL**

COMMENTS: **redrill; Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SANDSTONE: Fine grained, light, yellow, distinctly weathered
	SANDSTONE: Fine grained, light, reddish, brown, distinctly weathered
	CLAYSTONE: Light, reddish, brown, distinctly weathered
	CLAYSTONE: Light, yellowish, buff, distinctly weathered
Rewan Formation (Triassic)	CLAYSTONE: Dark, purplish, brown, distinctly weathered
	SANDSTONE: Fine grained, light, brown, distinctly weathered
	CLAYSTONE: Dark, purplish, brown, distinctly weathered
	CLAYSTONE: Light, brown, distinctly weathered
	CLAYSTONE: Light, purplish, brown, distinctly weathered
	CLAYSTONE: Light, yellowish, brown, distinctly weathered
	SANDSTONE: Fine grained, brown, distinctly weathered
	CLAYSTONE: Brownish, buff, distinctly weathered
	SANDSTONE: Fine to medium grained, brown, distinctly weathered
	CLAYSTONE: Brownish, buff, distinctly weathered
	SANDSTONE: Fine to medium grained, light, brown, distinctly weathered
	CLAYSTONE: Brownish, buff, distinctly weathered. BASE OF WEATHERING
	CLAYSTONE: Greenish, grey, fresh
	SANDSTONE: Fine grained, medium, greyish
	CLAYSTONE: Medium, greyish
	CLAYSTONE (70%) / SILTSTONE (30%): iron stained claystone, greenish, grey siltstone
	SILTSTONE: Greenish, grey, sandy, in part clayey in part



Bore Description

SWL at 103.5 mBGL on 23rd Jul 2013

Bentonite seal: 109.4 m to 111.4 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 111.4 m to 125.4 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 118.4 m to 125.4 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 125.4 m

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BOREHOLE LOG

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MB26

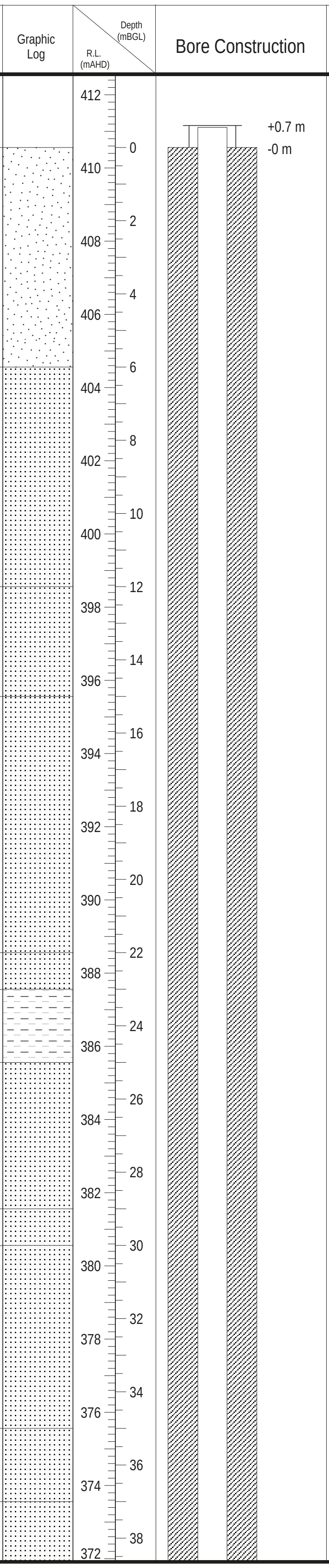
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **2-Jul-12**
LOGGED BY: **H.Donovan**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Air Rotary**

SITE ID: **Q29**
EASTING: **407115.2 mE**
NORTHING: **7601043.29 mN**
DATUM: **GDA94 (z55)**
RL: **410.56 mAHD**
TD: **119.6 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SAND : Very fine to fine grained, medium to dark, red, clayey, residual soil.
	SANDSTONE: Very fine to fine grained, medium to dark, reddish, brown, extremely weathered.
	SANDSTONE: Fine grained, medium, brownish, red, extremely weathered.
	SANDSTONE: Fine grained, medium, brownish, red, quartzose, extremely weathered.
	SANDSTONE: Very fine to fine grained, light to medium, brownish, yellow, extremely weathered.
	SILTSTONE: Medium, yellowish, orange, sandy, in part, extremely weathered.
	SANDSTONE: Fine grained, medium, yellowish, brown, extremely weathered.
	SANDSTONE: Very fine to fine grained, medium, reddish, brown, siltstone, extremely weathered.
	SANDSTONE: Very fine grained, light to medium, pinkish, red, extremely weathered.
	SANDSTONE: Very fine to fine grained, light to medium, blue, extremely weathered.
	SANDSTONE: Very fine grained, light, pinkish, cream, siltstone, in part, extremely weathered.



Bore Description

Protective lockable steel collar
PVC Stick up: 0.7 m

152 mm PCD bit: 0 m to 119.6 m

Bentonite grout: 0 m to 107.6 m

50 mm, PN18 uPVC, blank casing: 0.7 mAGL to 112.6 m

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BOREHOLE LOG

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MB26

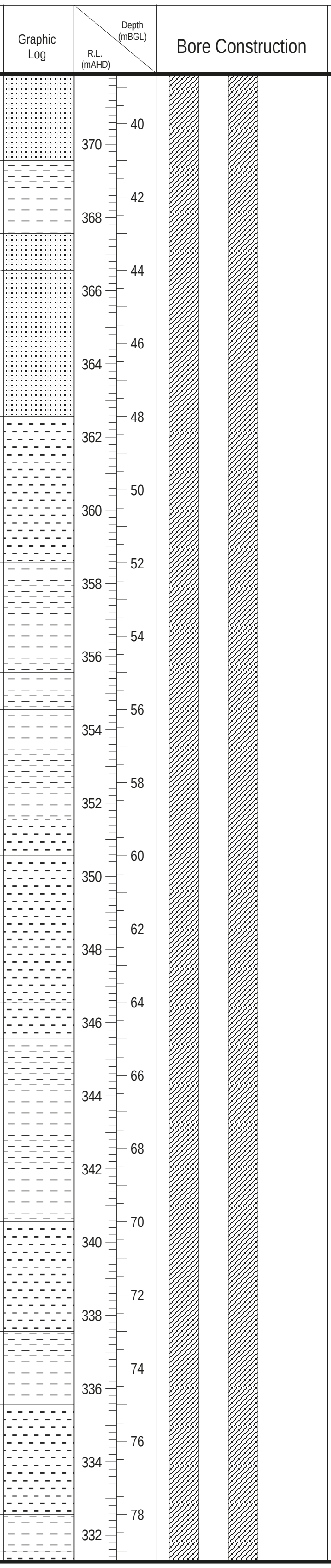
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **2-Jul-12**
LOGGED BY: **H.Donovan**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Air Rotary**

SITE ID: **Q29**
EASTING: **407115.2 mE**
NORTHING: **7601043.29 mN**
DATUM: **GDA94 (z55)**
RL: **410.56 mAHD**
TD: **119.6 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SANDSTONE: Very fine grained, light, pinkish, cream, siltstone, in part, extremely weathered.
	SILTSTONE: Light, pinkish, cream, clayey, near top of unit, extremely weathered.
	SANDSTONE: Very fine grained, light to medium, yellow, extremely weathered.
	SANDSTONE: Very fine to fine grained, light to medium, pinkish, brown, extremely weathered.
	CLAYSTONE: Light, pinkish, cream, distinctly weathered.
	SILTSTONE: Medium, yellowish, pink, distinctly weathered.
	SILTSTONE: Medium, pinkish, cream, distinctly weathered.
	SILTSTONE: Medium, yellow, distinctly weathered.
Rewan Formation (Triassic)	CLAYSTONE: Light, yellowish, cream, distinctly weathered.
	CLAYSTONE: Creamy, white, distinctly weathered.
	CLAYSTONE: Medium, yellowish, brown, distinctly weathered.
	SILTSTONE: Light to medium, yellowish, brown, clayey, near base of unit, distinctly weathered.
	CLAYSTONE: Light, whitish, yellow, clayey, near top of unit, distinctly weathered.
	SILTSTONE: Light to medium, greyish, yellow, clayey, slightly weathered.
	CLAYSTONE: Light to medium, yellowish, grey, siltstone, in part, slightly weathered.
	SILTSTONE: Light to medium, yellowish, brown, slightly weathered.



Bore Description

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BOREHOLE LOG

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MB26

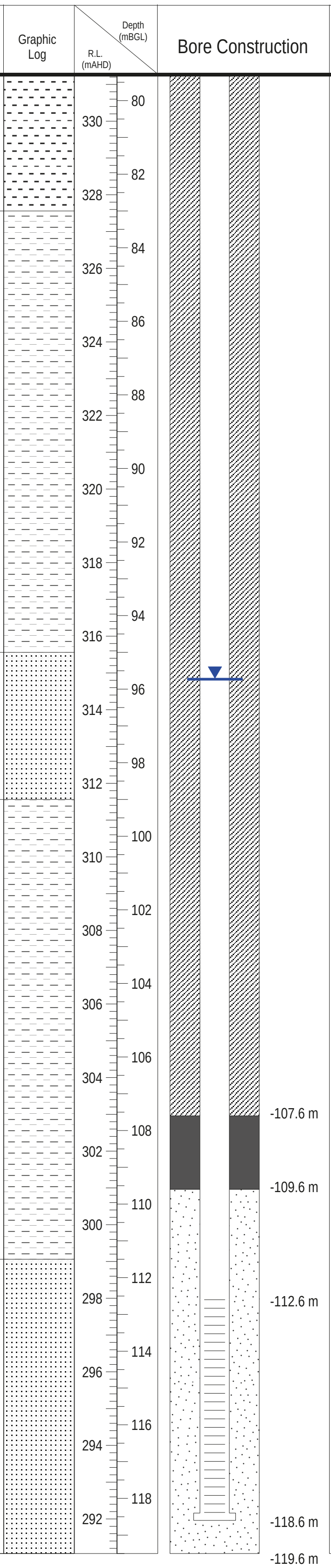
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **2-Jul-12**
LOGGED BY: **H.Donovan**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Air Rotary**

SITE ID: **Q29**
EASTING: **407115.2 mE**
NORTHING: **7601043.29 mN**
DATUM: **GDA94 (z55)**
RL: **410.56 mAHD**
TD: **119.6 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	CLAYSTONE: Light, yellowish, brown, slightly weathered.
	SILTSTONE: Medium, greenish, grey, clayey, throughout, fresh
	SANDSTONE: Very fine to fine grained, medium, greenish, brown, siltstone, in part.
	SILTSTONE: Medium to dark, greenish, grey, clayey, throughout, occasional, sandy.
	SANDSTONE: Fine grained, medium to dark, greenish, brown.



Bore Description

SWL at 95.73 mBGL on 22nd Jul 2013

Bentonite seal: 107.6 m to 109.6 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 109.6 m to 119.6 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 112.6 m to 118.6 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 118.6 m

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BOREHOLE LOG

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MB27

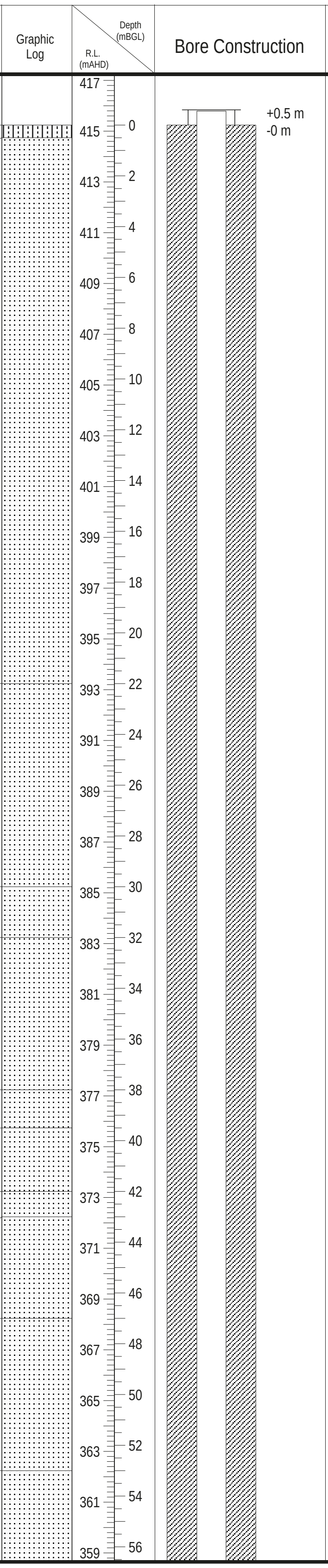
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **7-Jul-13**
LOGGED BY: **W.Han**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Air Rotary**

SITE ID: **Q28**
EASTING: **407958.5 mE**
NORTHING: **7600572.19 mN**
DATUM: **GDA94 (z55)**
RL: **415.24 mAHD**
TD: **113.6 mBGL**

COMMENTS: **redrill; casing dropped down hole**

Stratigraphic Interpretation	Soil or Rock Field Material Description	Bore Description
Clematis Sandstone (Triassic)	SOIL : Light to medium, brownish, red, sandy, residual soil.	Protective lockable steel collar PVC Stick up: 0.5 m (estimate)
	SANDSTONE: Fine grained, light to medium, yellowish, red, iron stained, in part, extremely weathered.	152 mm PCD bit: 0 m to 113.6 m Bentonite grout: 0 m to 99.6 m 50 mm, PN18 uPVC, blank casing: 0.5 mAGL to 106 m
	SANDSTONE: Fine to medium grained, light to medium, yellowish, red, extremely weathered.	
	SANDSTONE: Very fine to fine grained, light to medium, reddish, yellow, extremely weathered.	
	SANDSTONE: Very fine to fine grained, light, pinkish, yellow, extremely weathered.	
	SANDSTONE: Very fine to fine grained, light to medium, reddish, yellow, iron stained, in part, extremely weathered.	
	SANDSTONE: Fine to medium grained, light to medium, yellow, extremely weathered.	
	SANDSTONE: Medium grained, light to medium, yellow, extremely weathered.	
	SANDSTONE: Fine grained, light to medium, pinkish, yellow, iron stained, extremely weathered.	
	SANDSTONE: Fine to medium grained, light to medium, reddish, yellow, extremely weathered.	
	SANDSTONE: Fine grained, light to medium, pinkish, yellow, iron stained, in part, extremely weathered.	



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BOREHOLE LOG

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MB27

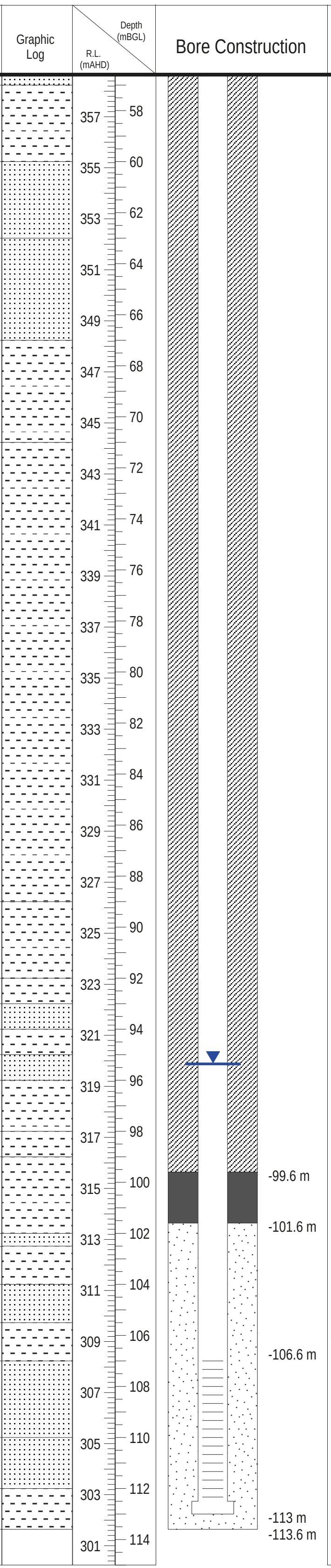
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **7-Jul-13**
LOGGED BY: **W.Han**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Air Rotary**

SITE ID: **Q28**
EASTING: **407958.5 mE**
NORTHING: **7600572.19 mN**
DATUM: **GDA94 (z55)**
RL: **415.24 mAHD**
TD: **113.6 mBGL**

COMMENTS: **redrill; casing dropped down hole**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	CLAYSTONE: Light to medium, pinkish, cream, extremely weathered.
	SANDSTONE: Fine grained, light, creamy, yellow, extremely weathered.
	SANDSTONE: Very fine to fine grained, dark, brownish, red, extremely weathered.
	CLAYSTONE: Medium, pinkish, cream, extremely weathered.
Rewan Formation (Triassic)	CLAYSTONE: Light, brownish, orange, extremely weathered.
	CLAYSTONE: Medium, yellowish, cream, extremely weathered.
	CLAYSTONE: Dark, yellow, extremely weathered.
	SANDSTONE: Fine grained, medium, orange, extremely weathered.
	CLAYSTONE: Light, greyish, cream, extremely weathered.
	SANDSTONE: Fine grained, medium, orange, extremely weathered.
	CLAYSTONE: Dark, orange, extremely weathered.
	CLAYSTONE: Light, greyish, cream, distinctly weathered.
	CLAYSTONE: Medium, greenish, grey, fresh.
	SANDSTONE: Very fine to fine grained, medium, greenish, grey.
	CLAYSTONE: Medium, greenish, grey.
	SANDSTONE: Very fine to fine grained, medium, greenish, grey.
	CLAYSTONE: Medium, greenish, grey.
	SANDSTONE: Fine grained, medium, greenish, grey.
	SANDSTONE: Fine to medium grained, medium, greenish, grey, claystone, bands.
	CLAYSTONE: Medium, greenish, grey.



Bore Description

bore dry at the time of drilling
SWL at 95.36 mBGL on 6th Mar 2014

Bentonite seal: 99.6 m to 101.6 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 101.6 m to 113.6 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 106 m to 113 m
slots opened to 1 mm every metre for stygofauna sampling

BOC: 113 m

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BOREHOLE LOG

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MB28

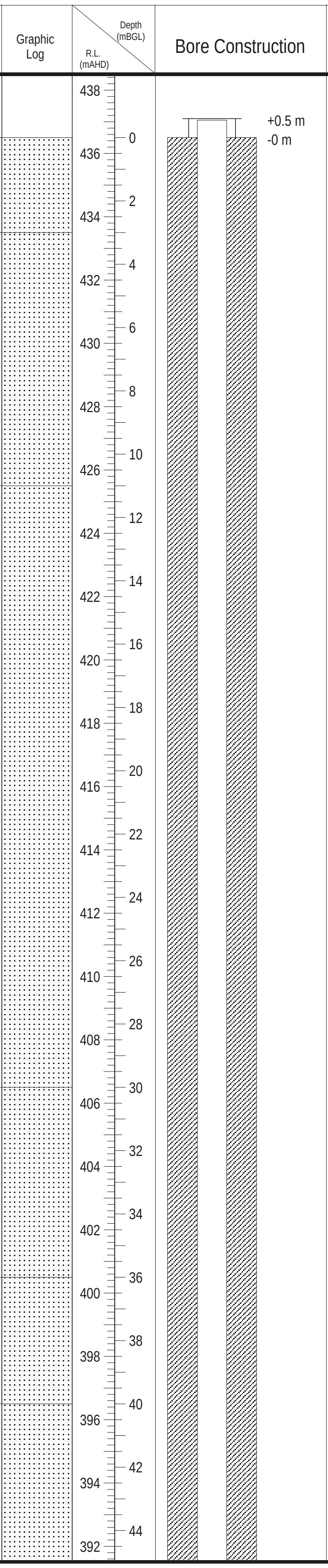
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **1-Jun-13**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **S.Colles (3313)**
DRILLING METHOD: **Mud Rotary**

SITE ID: **Q26**
EASTING: **409795.56 mE**
NORTHING: **7599782.67 mN**
DATUM: **GDA94 (z55)**
RL: **436.5 mAHD**
TD: **138 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description	Bore Description
Clematis Sandstone (Triassic)	SANDSTONE: Very fine grained, red, iron stained, extremely weathered	Protective lockable steel collar PVC Stick up: 0.5 m (estimate)
	SANDSTONE: Fine grained, dark, red, iron stained, extremely weathered	152 mm PCD bit: 0 m to 138 m Bentonite grout: 0 m to 124 m
	SANDSTONE: Medium grained, dark, red, iron stained,, extremely weathered	50 mm, PN18 uPVC, blank casing: 0.5 mAGL to 132 m
	SANDSTONE: Coarse grained, dark, red, quartzose, iron stained, distinctly weathered	
	SANDSTONE: Fine grained, red, iron stained, distinctly weathered	
	SANDSTONE: Very fine grained, light, whitish, red, iron stained, distinctly weathered	



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MB28

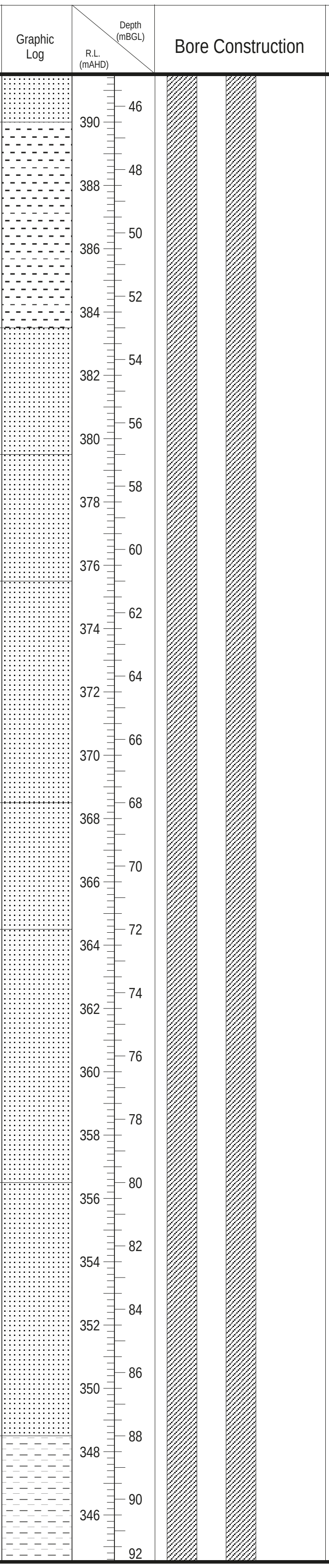
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **1-Jun-13**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **S.Colles (3313)**
DRILLING METHOD: **Mud Rotary**

SITE ID: **Q26**
EASTING: **409795.56 mE**
NORTHING: **7599782.67 mN**
DATUM: **GDA94 (z55)**
RL: **436.5 mAHD**
TD: **138 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description	Bore Description
Clematis Sandstone (Triassic)		
	CLAYSTONE: Light, whitish, brown, lateritic, extremely weathered	
	SANDSTONE: Fine grained, light, pinkish, brown, lateritic, extremely weathered	
	SANDSTONE: Fine grained, light, reddish, brown, iron stained, distinctly weathered	
	SANDSTONE: Medium grained, light, reddish, brown, iron stained, distinctly weathered	
Rewan Formation (Triassic)	SANDSTONE: Fine grained, light, yellowish, brown, silty, in part, distinctly weathered	
	SANDSTONE: Fine grained, light, reddish, brown, distinctly weathered	
	SANDSTONE: Very fine grained, light, yellowish, brown, distinctly weathered	
	SILTSTONE: Light, yellowish, brown, distinctly weathered	



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MB28

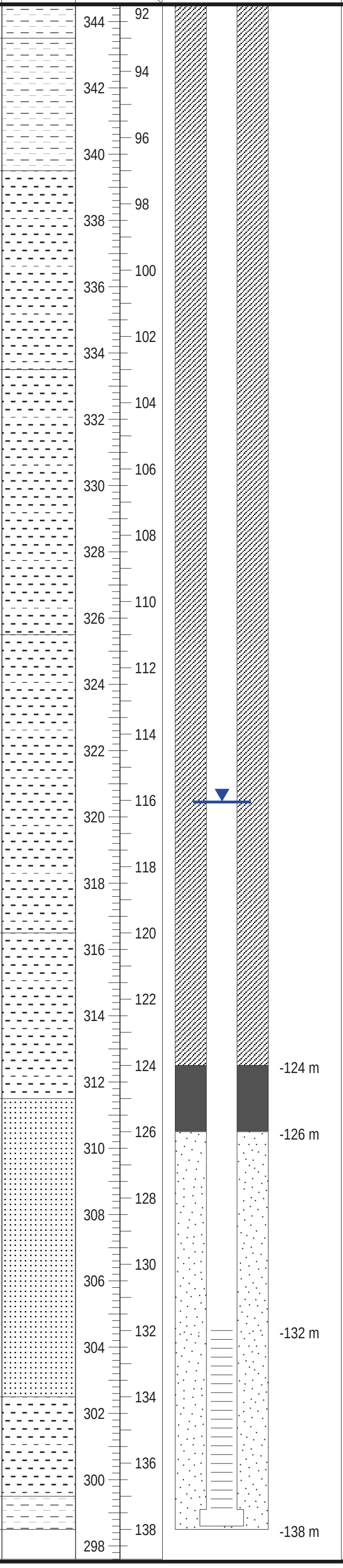
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **1-Jun-13**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **S.Colles (3313)**
DRILLING METHOD: **Mud Rotary**

SITE ID: **Q26**
EASTING: **409795.56 mE**
NORTHING: **7599782.67 mN**
DATUM: **GDA94 (z55)**
RL: **436.5 mAHD**
TD: **138 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	
	SITLSTONE (50%) / CLAYSTONE (50%): Light, yellowish, blue, slightly weathered
	CLAYSTONE: Light, yellowish, blue. BASE OF WEATHERING.
	CLAYSTONE: Bluish, grey.
	CLAYSTONE: Light, grey, silty, near base of unit
	SANDSTONE (50%) / CLAYSTONE (50%): 50% very fine grained, light, grey
	SANDSTONE: Fine grained, light, grey
	CLAYSTONE: Light, grey, silty, throughout
	SILTSTONE: Light, grey



Bore Description

SWL at 116.05 mBGL on 6th Jul 2013

Bentonite seal: 124 m to 126 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 126 m to 138 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 132 m to 138 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 138 m

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MB29

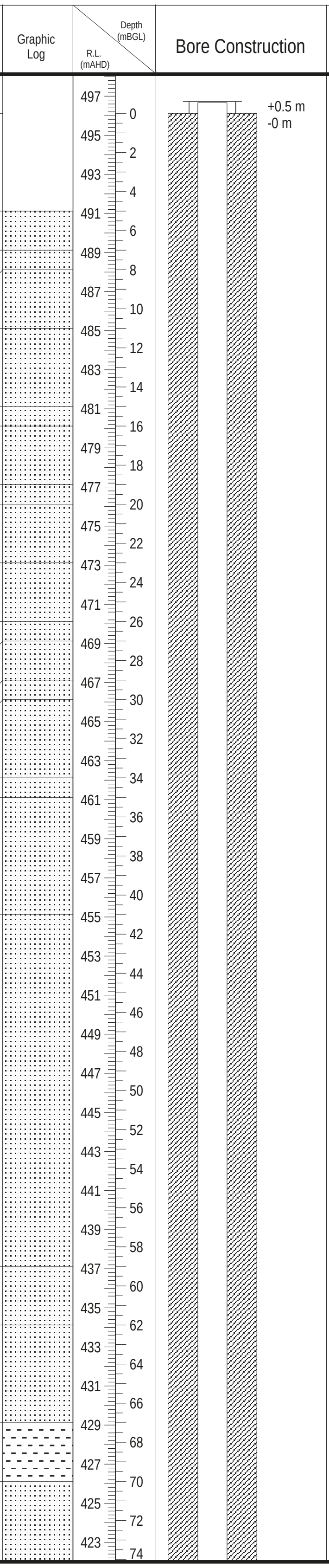
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **9-Sep-13**
LOGGED BY: **A.Tarr**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Mud Rotary**

SITE ID: **Y36**
EASTING: **407367.07 mE**
NORTHING: **7608867.12 mN**
DATUM: **GDA94 (z55)**
RL: **496.12 mAHD**
TD: **149 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	NO RECOVERY:
	SANDSTONE: Very fine grained, light, whitish, cream, quartzose, extremely weathered.
	SANDSTONE: Very fine grained, dark, brownish, red, extremely weathered.
	SANDSTONE: Very fine grained, light, whitish, cream, extremely weathered.
	SANDSTONE: Very fine grained, light, pinkish, yellow, minor, micaceous, extremely weathered.
	SANDSTONE: Very fine grained, light, whitish, grey.
	SANDSTONE: Very fine grained, light, whitish, grey.
	SANDSTONE: Very fine grained, dark, brownish, red.
	SANDSTONE: Very fine to fine grained, light, creamy, yellow, quartzose.
	SANDSTONE: Very fine to fine grained, light, greyish, cream, quartzose, throughout.
	SANDSTONE: Fine to medium grained, light, greyish, cream, quartzose, throughout.
	SANDSTONE: Very fine to fine grained, light, greyish, cream, quartzose, throughout.
	SANDSTONE: Very fine grained, light, pinkish, cream.
	SANDSTONE: Very fine to fine grained, light, greyish, cream, quartzose, micaceous.
	SANDSTONE: Coarse grained, light, greyish, cream, quartzose.
	SANDSTONE: Granular, light, yellowish, grey, quartzose.
	SANDSTONE: Coarse grained, light, greyish, yellow, quartzose, minor, micaceous.
	SANDSTONE: Very fine to fine grained, light, yellowish, grey, claystone, bands, throughout.
	SANDSTONE: Fine to medium grained, light, greyish, yellow, quartzose.
	CLAYSTONE: Mottled, creamy, red.
	SANDSTONE: Coarse grained, light, greyish, yellow, quartzose.



Bore Description

Protective lockable steel collar
PVC Stick up: 0.5 m (estimate)

165 mm PCD bit: 0 m to 149 m

Bentonite grout: 0 m to 135 m

50 mm, PN18 uPVC, blank casing: 0.5 mAGL to 142 m

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MB29

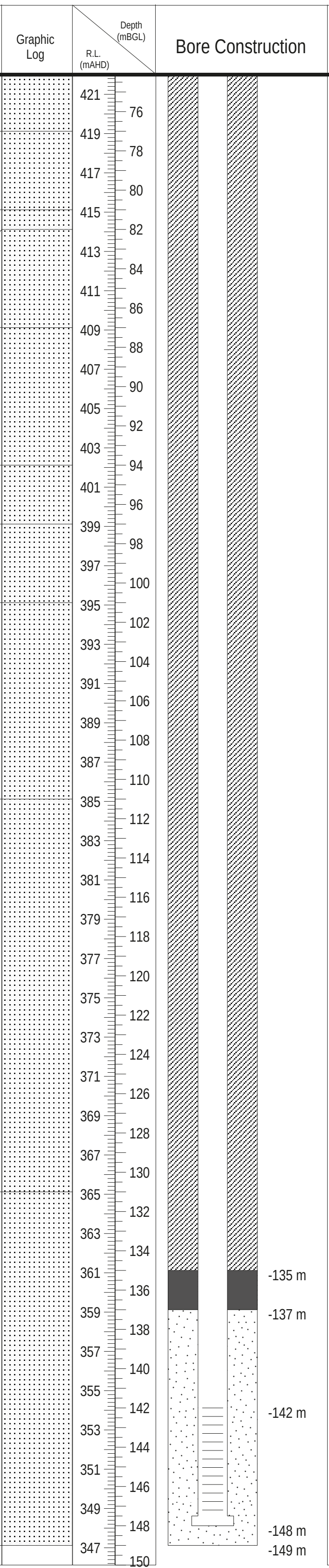
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **9-Sep-13**
LOGGED BY: **A.Tarr**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Mud Rotary**

SITE ID: **Y36**
EASTING: **407367.07 mE**
NORTHING: **7608867.12 mN**
DATUM: **GDA94 (z55)**
RL: **496.12 mAHD**
TD: **149 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	
	SANDSTONE: Very fine to fine grained, light, greyish, yellow, quartzose.
	SANDSTONE: Very fine to fine grained, light, pinkish, yellow, quartzose.
	SANDSTONE: Medium to coarse grained, light, orangy, yellow, quartzose.
	SANDSTONE: Medium to coarse grained, light, pinkish, yellow, quartzose.
	SANDSTONE: Fine to coarse grained, light, orangy, yellow, quartzose.
	SANDSTONE: Very fine to fine grained, pinkish, yellow.
	SANDSTONE: Very fine grained, light, creamy, pink.
	SANDSTONE: Very fine grained, light, creamy, yellow, minor, claystone, bands.
	SANDSTONE: Very fine grained, mottled, creamy, pink, minor, claystone, extremely weathered.



Bore Description

bore dry at the time of drilling
bore dry at 19th March 2014

Bentonite seal: 135 m to 137 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 137 m to 149 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 142 m to 148 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 148 m

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MB30

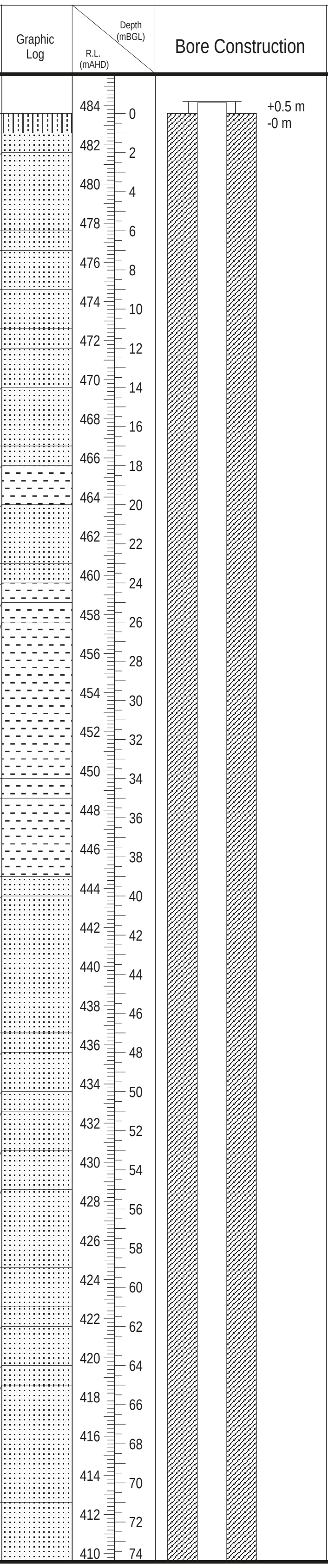
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **10-Oct-13**
LOGGED BY: **A. Dela Cruz**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Air Rotary**

SITE ID: **AA35**
EASTING: **409938.88 mE**
NORTHING: **7609490.59 mN**
DATUM: **GDA94 (z55)**
RL: **483.61 mAHD**
TD: **149.3 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SOIL : Light, brownish, brown, minor, extremely weathered, stiff.
	SANDSTONE: Very fine grained, light, white, minor, sandstone, extremely weathered, extremely low strength rock
	SANDSTONE: Very fine grained, light, white, extremely weathered, extremely low strength rock.
	SANDSTONE: Very fine grained, light, whitish, buff.
	SANDSTONE: Very fine grained, light, brown, extremely weathered, extremely low strength rock.
	SANDSTONE: Very fine grained, light, yellowish, brown.
	SANDSTONE: Very fine grained, light to medium, brown, extremely weathered, extremely low strength rock.
	SANDSTONE: Very fine grained, light, whitish, buff, extremely weathered, extremely low strength rock.
	SANDSTONE: Very fine grained, buff, extremely weathered, extremely low strength rock.
	SANDSTONE: Very fine to fine grained, medium to dark, brown, extremely weathered, extremely low strength rock.
	CLAYSTONE: Light, cream, extremely weathered, extremely low strength rock.
	SANDSTONE: Very fine to fine grained, light, brownish, white, extremely weathered, extremely low strength rock.
	SANDSTONE: Very fine to fine grained, medium to dark, red, extremely weathered, extremely low strength rock.
	CLAYSTONE: Light, brownish, cream, extremely weathered, extremely low strength rock.
	CLAYSTONE: Light, whitish, grey, extremely weathered, extremely low strength rock.
	CLAYSTONE:
	CLAYSTONE: Light, grey, distinctly weathered, medium strength rock
	CLAYSTONE: Light, brownish, cream.
	SANDSTONE: Very fine to fine grained, light to dark, red, weathered, extremely low strength rock.
	SANDSTONE: Very fine to fine grained, light, creamy, white, weathered, extremely low strength rock.
	SANDSTONE: Fine to medium grained, light, creamy, buff, weathered, extremely low strength rock.
	SANDSTONE: Coarse grained, light, creamy, buff, quartzose, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, creamy, buff, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, grey, distinctly weathered, extremely low strength rock.
	SANDSTONE: Coarse grained, light, creamy, buff, quartzose, weathered, extremely low strength rock.
	SANDSTONE: Medium to coarse grained, light, creamy, buff, quartzose, weathered, extremely low strength rock
	SANDSTONE: Granular, light, creamy, buff, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, whitish, buff, weathered, extremely low strength rock.
	SANDSTONE: Fine to medium grained, light, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine to medium grained, light to medium, brown, weathered, extremely low strength rock.
	SANDSTONE: Coarse grained, light, creamy, buff, quartzose, weathered, extremely low strength rock.
	SANDSTONE: Fine to medium grained, light, creamy, buff, weathered, extremely low strength rock.



Bore Description

Protective lockable steel collar
PVC Stick up: 0.5 m (estimate)

152 mm PCD bit: 0 m to 149.3 m

Bentonite grout: 0 m to 135.3 m

50 mm, PN18 uPVC, blank casing: 0.5 mAGL to 149.3 m

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BOREHOLE LOG

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MB30

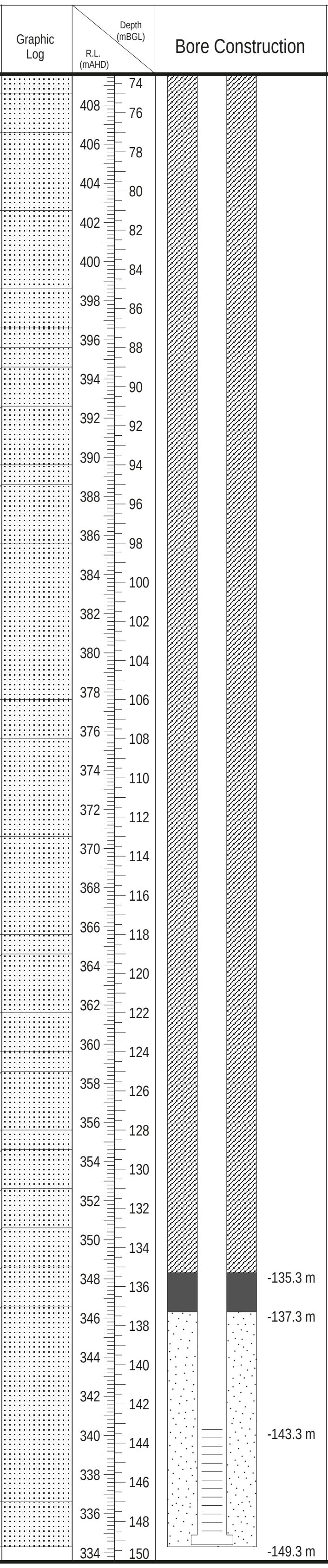
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **10-Oct-13**
LOGGED BY: **A. Dela Cruz**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **D.Quinlan (3084)**
DRILLING METHOD: **Air Rotary**

SITE ID: **AA35**
EASTING: **409938.88 mE**
NORTHING: **7609490.59 mN**
DATUM: **GDA94 (z55)**
RL: **483.61 mAHD**
TD: **149.3 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SANDSTONE: Fine grained, light, reddish, brown, weathered, extremely low strength rock.
	SANDSTONE: Medium to coarse grained, light, reddish, brown, quartzose, weathered, extremely low strength rock
	SANDSTONE: Medium to coarse grained, light, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine to medium grained, light, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine to coarse grained, light, orangy, brown.
	SANDSTONE: Fine to medium grained, light to dark, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine to medium grained, light, yellowish, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine to medium grained, light, brownish, buff, weathered, extremely low strength rock.
	SANDSTONE: Fine to medium grained, light, reddish, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine to medium grained, light, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, yellowish, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, reddish, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine to coarse grained, light, reddish, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, reddish, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, pinkish, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, reddish, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine to medium grained, light, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, brownish, buff, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, reddish, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, brown, weathered, medium strength rock.
	SANDSTONE: Fine grained, medium, reddish, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, light, reddish, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine to medium grained, light to dark, reddish, brown, weathered, extremely low strength rock.
	SANDSTONE: Fine grained, medium, reddish, brown, weathered, extremely low strength rock.



Bore Description

bore dry at the time of drilling, still dry on the 19th March 2014

Bentonite seal: 135.3 m to 137.3 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 137.3 m to 149.3 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 143.3 m to 149.3 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 149.3 m

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BOREHOLE LOG

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MB31

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **22-Sep-13**
LOGGED BY: **T. Womack**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **J.Freeman (3335)**
DRILLING METHOD: **Air / Mud Rotary**

SITE ID: **CC41**
EASTING: **406704.71 mE**
NORTHING: **7613341.6 mN**
DATUM: **GDA94 (z55)**
RL: **468.55 mAHD**
TD: **149.4 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description	Graphic Log	Bore Construction	Bore Description
Clematis Sandstone (Triassic)	SANDSTONE: Fine grained, light to medium, greyish, orange, distinctly weathered, very low strength rock.	▒		
	SANDSTONE: Fine grained, light to medium, pinkish, orange, distinctly weathered, very low strength rock.	▒		
	SANDSTONE: Very fine to fine grained, light, pinkish, grey, distinctly weathered, extremely low strength rock	▒		
	SANDSTONE: Very fine grained, light, pinkish, grey, distinctly weathered, extremely low strength rock.	▒		
	SANDSTONE: Very fine grained, light, greyish, pink, distinctly weathered, extremely low strength rock.	▒		
	SANDSTONE: Very fine grained, light, pinkish, grey, distinctly weathered, extremely low strength rock.	▒		
	SANDSTONE: Very fine grained, light, yellowish, grey, distinctly weathered, extremely low strength rock.	▒		
	SANDSTONE: Fine grained, light, pinkish, grey, quartzose, slightly weathered.	▒		
	SANDSTONE: Fine grained, light, pinkish, grey, quartzose, slightly weathered.	▒		
	SANDSTONE: Coarse grained, light, orangy, grey, quartzose.	▒		
	SANDSTONE: Very fine grained, light, orangy, grey, claystone, in part, distinctly weathered, extremely low strength rock.	▒		
	SANDSTONE: Fine to coarse grained, light, orangy, grey, quartzose, distinctly weathered.	▒		
	SANDSTONE: Very fine grained, light, creamy, grey, slightly weathered.	▒		
		▒		

R.L. (mAHD)	Depth (mBGL)
469	0
467	2
465	4
463	6
461	8
459	10
457	12
455	14
453	16
451	18
449	20
447	22
445	24
443	26
441	28
439	30
437	32
435	34
433	36
431	38
429	40
427	42
425	44
423	46
421	48
419	50
417	52
415	54
413	56
411	58
409	60
407	62
405	64
403	66
401	68
399	70
397	72
395	74

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BOREHOLE LOG

MB31

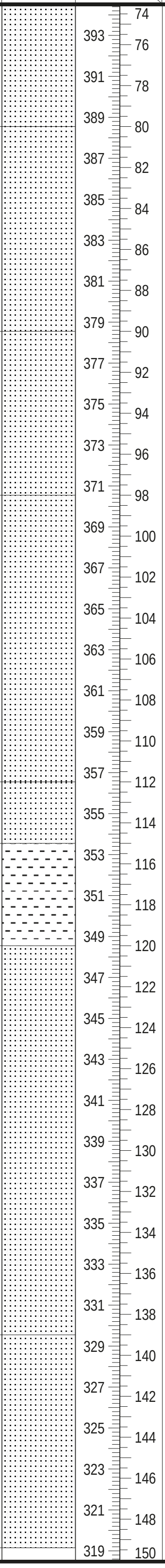
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **22-Sep-13**
LOGGED BY: **T. Womack**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **J.Freeman (3335)**
DRILLING METHOD: **Air / Mud Rotary**

SITE ID: **CC41**
EASTING: **406704.71 mE**
NORTHING: **7613341.6 mN**
DATUM: **GDA94 (z55)**
RL: **468.55 mAHD**
TD: **149.4 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
Clematis Sandstone (Triassic)	SANDSTONE: Very fine to fine grained, light, pinkish, orange, distinctly weathered.				
	SANDSTONE: Fine to coarse grained, light, orangy, grey, quartzose, slightly weathered.				
	SANDSTONE: Fine to medium grained, light to medium, orangy, grey, quartzose, distinctly weathered.				
	SANDSTONE: Fine to coarse grained, medium, greyish, orange, quartzose, distinctly weathered.				
	SANDSTONE: Very fine grained, light, pinkish, grey, slightly weathered.				
	CLAYSTONE: Medium, greyish, orange, sandstone, in part.				
	SANDSTONE: Very fine grained, light to medium, orangy, grey, occasional, claystone, fragments, distinctly weathered, very low strength				
	SANDSTONE: Very fine to fine grained, medium, orangy, grey, claystone, in part, distinctly weathered.				



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BOREHOLE LOG

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MB32

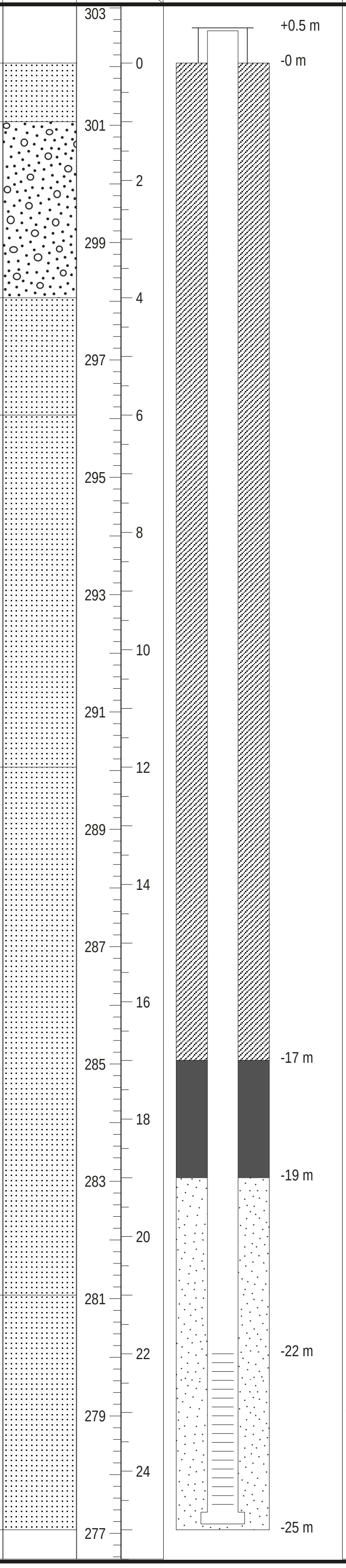
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **1-Jun-13**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **S.Colles (3313)**
DRILLING METHOD: **Air Rotary**

SITE ID: **MN9.5**
EASTING: **420523.99 mE**
NORTHING: **7590538.25 mN**
DATUM: **GDA94 (z55)**
RL: **302.06 mAHD**
TD: **25 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SANDSTONE: Fine grained, light, brown, extremely weathered
	GRAVEL CONGLOMERATE: Light, yellowish, brown, quartzose, extremely weathered
	SANDSTONE: Fine grained, light, red, extremely weathered
	SANDSTONE: Medium to coarse grained, light, yellowish, brown, quartzose, pebbles, in part, extremely weathered
	SANDSTONE: Medium to coarse grained, light, yellowish, brown, quartzose, extremely weathered
	SANDSTONE: Fine to medium grained, red, distinctly weathered



Bore Description

Protective lockable steel collar

PVC Stick up: 0.5 m (estimate)

165 mm PCD bit: 0 m to 25 m

Bentonite grout: 0 m to 17 m

50 mm, PN18 uPVC, blank casing: 0.5 mAGL to 22 m

Bentonite seal: 17 m to 19 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 19 m to 25 m

bore dry at the time of drilling, still dry on the 19th March 2014

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 22 m to 25 m
slots opened to 1 mm every metre for stygofauna sampling

BOC: 25 m

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BOREHOLE LOG

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MB33

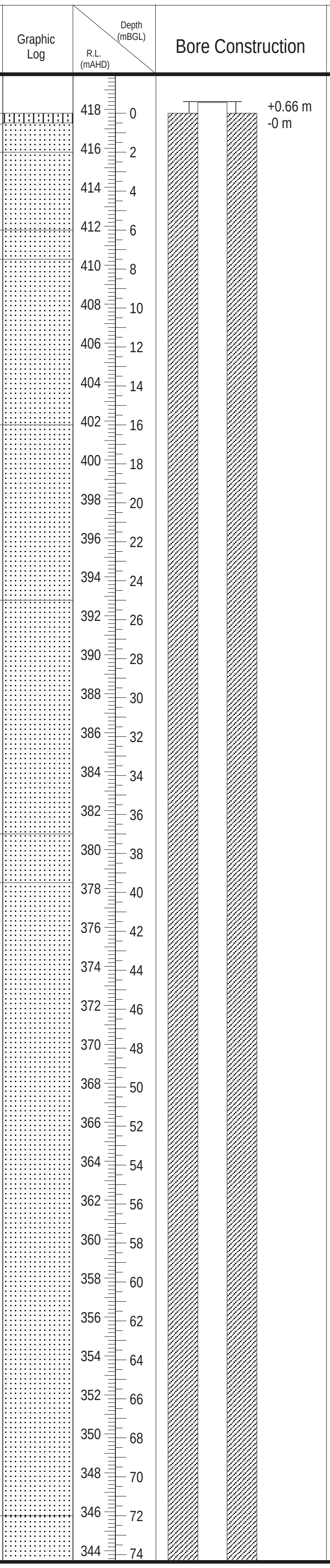
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **6-Jun-13**
LOGGED BY: **B. Walker**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **J.Freeman (3335)**
DRILLING METHOD: **Mud Rotary**

SITE ID: **T32**
EASTING: **407078.76 mE**
NORTHING: **7604220.71 mN**
DATUM: **GDA94 (z55)**
RL: **417.8 mAHD**
TD: **149.4 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SOIL: Reddish, brown, weathered
	SANDSTONE: Fine to medium grained, reddish, brown, weathered
	SANDSTONE: Fine to coarse grained, reddish, brown, weathered
	SANDSTONE: Granular to pebbly, brown, weathered
	SANDSTONE: Very fine to fine grained, reddish, brown, weathered
	SANDSTONE: Fine to coarse grained, brown, weathered
	SANDSTONE: Fine grained, brown, coarser near middle of unit, weathered
	SANDSTONE: Granular to pebbly, brown, weathered
	SANDSTONE: Fine to coarse grained, light, brownish, cream, coarser near top of unit near middle of unit, weathered



Bore Description

Protective lockable steel collar
PVC Stick up: 0.66 m

152 mm PCD bit: 0 m to 149.4 m

Air rotary from 0 m to 53 m

Mud rotary from 53 m to 149.4 m

Bentonite grout: 0 m to 135 m

50 mm, PN18 uPVC, blank casing: 0.66 mAGL to 149.4 m

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

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MB33

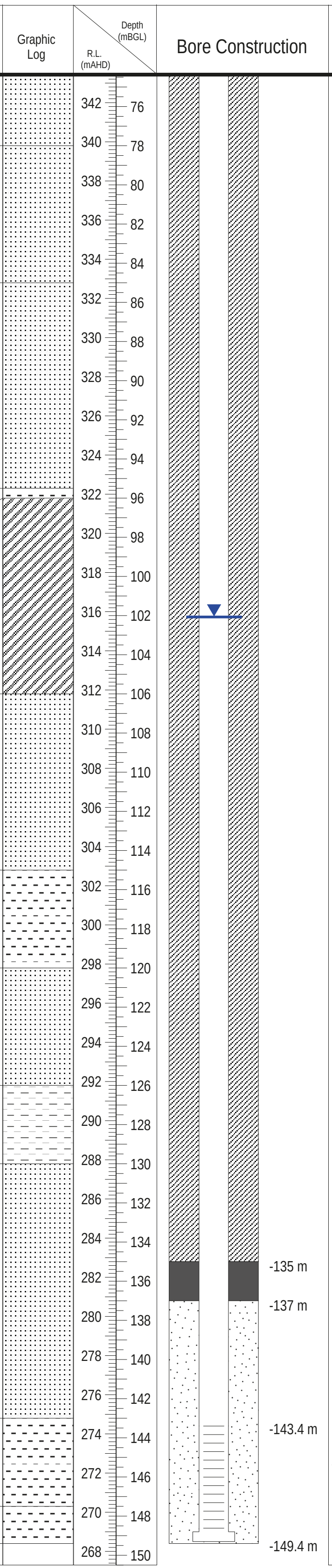
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **6-Jun-13**
LOGGED BY: **B. Walker**

DRILLING COMPANY: **Watson Drilling**
LICENCED DRILLER: **J.Freeman (3335)**
DRILLING METHOD: **Mud Rotary**

SITE ID: **T32**
EASTING: **407078.76 mE**
NORTHING: **7604220.71 mN**
DATUM: **GDA94 (z55)**
RL: **417.8 mAHD**
TD: **149.4 mBGL**

COMMENTS:

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SANDSTONE: Granular, mottled, brown, weathered
	SANDSTONE: Fine to coarse grained, brown, weathered
	SANDSTONE: Fine to coarse grained, creamy, finer near top of unit, coarser near base of unit, weathered
	CLAYSTONE: Whitish, cream, weathered
	LATERITE: Mottled, creamy, purple, sandy near base of unit, silty, weathered.
	SANDSTONE: Very fine to fine grained, light, brown, minor clayey bands near base of unit, weathered
	CLAYSTONE: Whitish, cream, weathered
	SANDSTONE: Very fine to fine grained, light, brown, weathered
	SILTSTONE: Light, brown, clayey in part, occasional carbonaceous bands, weathered
	SANDSTONE: Light, brown, minor carbonaceous bands near top of unit, weathered
Rewan Formation (Triassic)	CLAYSTONE: Light, creamy, brown, weathered. BASE OF WEATHERING
	CLAYSTONE: Grey, fresh



Bore Description

bore dry at the time of drilling
SWL at 102.07 mBGL on 4th Jul 2013

Bentonite seal: 135 m to 137 m

3 mm to 6 mm washed, rounded, quartz gravel pack: 137 m to 149.4 m

50 mm, PN18 uPVC, machine slotted casing with 0.4 mm aperture: 143.4 m to 149.4 m slots opened to 1 mm every metre for stygofauna sampling

BOC: 149.4 m

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BOREHOLE LOG

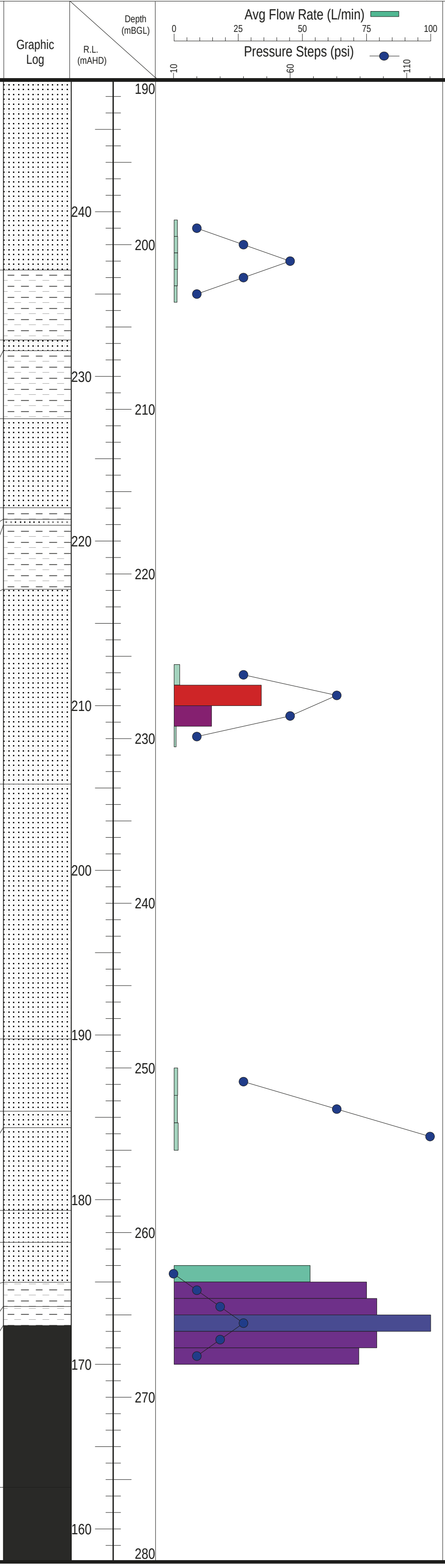
BOREHOLE ID: **MC5040A (Packer Test)** page:1 of 1

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **4th Jul 2013**
LOGGED BY: **J. Souter**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **Rob / Scott**
No. OF TEST INTERVALS: **4**
TEST OPERATOR: **H. McCarthy (AGE)**

SITE ID: **Q26**
EASTING: **409799.7 mE**
NORTHING: **7599741.5 mN**
DATUM: **GDA94 (z55)**
RL: **438 mAHD**
TD: **357.2 mBGL**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	SANDSTONE: Fine to medium grained, greenish, grey, low strength
	SILTSTONE: Light to medium, grey
	SANDSTONE: Fine to medium grained, light to medium,greenish, grey
	SILTSTONE: Light to medium, grey, sandy, bands
	SANDSTONE: Fine to medium grained, light to medium,greenish, grey
	SILTSTONE: Medium, grey, sandy, bands
Betts Creek Beds (Permian)	SANDSTONE: Light to medium, greenish, grey, silty, bands
	SILTSTONE: Light to medium, grey, sandy, bands
	SANDSTONE: Light to medium, greenish, grey, silty, bands, carbonaceous, wisps
	SANDSTONE: Fine to medium grained, light, grey
	SANDSTONE: Fine to medium grained, grey, low strength rock
	SANDSTONE: Fine to medium grained, grey, low strength rock, carbonaceous laminae
	SANDSTONE: Fine to medium grained, light, grey, low strength rock
	SANDSTONE: Fine to medium grained, light, grey
	SANDSTONE: Fine to medium grained, light to medium, grey, silty, bands
	SILTSTONE: Medium, grey, sandy, in part, carbonaceous, near base of unit
	SILTSTONE: Speckled, greyish, black, carbonaceous
A Seam	COAL: Dull <1% bright, tuff bands, AU4 to AU1
	COAL: Dull <1% bright, tuff bands, AL4 to AL3



Packer Test Description

TEST #: 4
TEST INTERVAL: 198.5 - 203.5 m
LITHOLOGY: Rewan Overburden
INTERPRETED K: 1.18 x 10-3 m/day

TEST #: 3
TEST INTERVAL: 225.5 - 230.5 m
LITHOLOGY: Permian Overburden
INTERPRETED K: 7.13 x 10-3 m/day

TEST #: 2
TEST INTERVAL: 250 - 255 m
LITHOLOGY: Permian Overburden
INTERPRETED K: 1.68 x 10-3 m/day

TEST #: 1
TEST INTERVAL: 262 - 357.2 m
LITHOLOGY: Open hole
INTERPRETED K: 5.7 x 10-3 m/day

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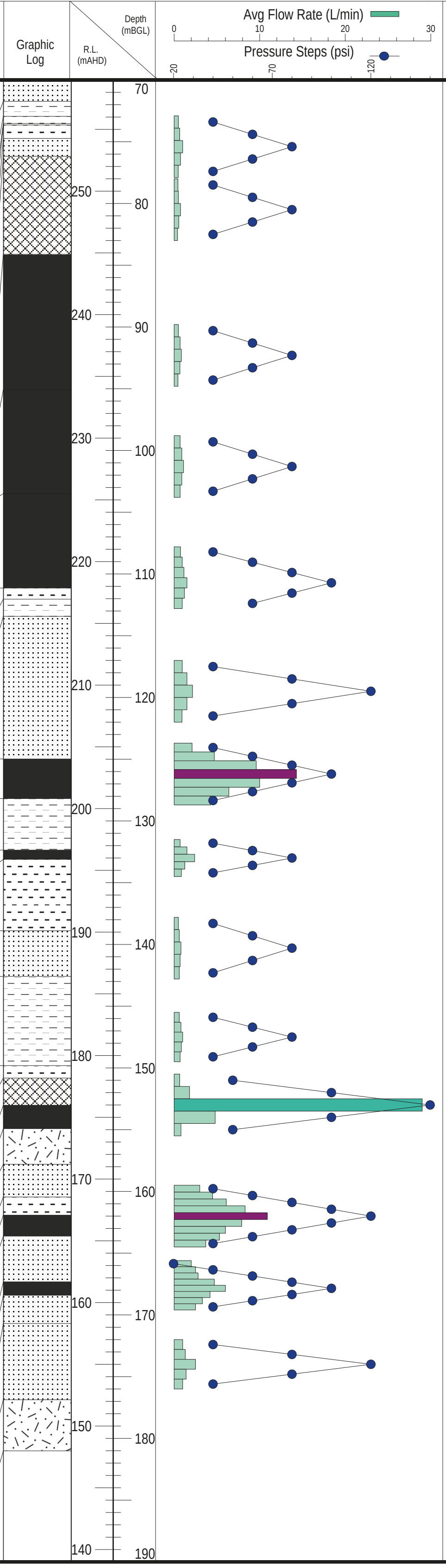
BOREHOLE LOG

BOREHOLE ID: **MC5041 (Packer Test)** page:1 of 1

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **25th Jun 2013**
LOGGED BY: **A. Goldsmith**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **A. Moore**
No. OF TEST INTERVALS: **14**
TEST OPERATOR: **H. McCarthy (AGE)**

SITE ID: **E7**
EASTING: **416369 mE**
NORTHING: **7584478 mN**
DATUM: **GDA94 (z55)**
RL: **329 mAHD**
TD: **190 mBGL**



Stratigraphic Interpretation

- Betts Creek Beds (Permian)
- A Seam
- B Seam
- Betts Creek Beds (Permian)
- C Seam
- Betts Creek Beds (Permian)

Soil or Rock Field Material Description

SANDSTONE: Medium to coarse grained, light, brownish, buff, rare, carbonaceous, laminae, slightly weathered, low strength

SILTSTONE: Dark, blackish, grey,carbonaceous, laminae, throughout, fresh, very low strength rock, claystone bands

CLAYSTONE: Dark, blackish, grey, sideritic, nodules, very low strength rock, laminated

SIDERITE: Light, reddish, brown, sandy, medium strength

CLAYSTONE: Black, very low strength rock, laminated, bands of sandstone/siltstone

SANDSTONE: Dark, brownish, grey, tuffaceous, carbonaceous, laminae, low strength

CARBONACEOUS CLAYSTONE: Dark, greyish, black, tuffaceous, sandy, phases, low strength rock, laminated

COAL: 1-40% bright, tuff bands, AU4 to AU1 seams

COAL: 1-10% bright, tuff bands, AL4 to AL1 seams

COAL: 1-10% bright, tuff bands, B3 to B1 seams

CLAYSTONE: Light, whitish, grey, tuffaceous, carbonaceous, laminae, very low strength

SILTSTONE: Light, grey, sandy, with carbonaceous claystone bands

SANDSTONE: Medium to coarse grained, light, grey, medium strength

COAL: 1-10% bright, B4 / C3 seams

SILTSTONE: Light, grey, low strength rock, thinly laminated, with siderite and claystone bands

COAL: 1-40% bright, C2 seam

CLAYSTONE: Dark, grey, very low strength, with sandstone/siltstone bands

SANDSTONE: Medium grained, light, grey, with bands of siltstone

SILTSTONE: Grey, clayey, bands, very low strength, with sandstone bands

CLAYSTONE: Grey, rare, silty, laminae, very low strength

CARBONACEOUS CLAYSTONE: Black, low strength rock

COAL: 1-40% bright, D1 seam

TUFF: Light, greyish, buff, clayey, very low strength

SANDSTONE: Fine grained, light, grey, silty, laminae, with siltstone bands

CLAYSTONE: Dark, grey, low strength rock

COAL: 1-90% bright, E1 seam

SANDSTONE: Medium to coarse grained, light, grey, carbonaceous, laminae, medium strength with siltstone bands

COAL: 1-40% bright, F seam

SANDSTONE: Fine to medium grained, light, grey, with siltstone bands

SANDSTONE: Granular, light, grey, quartzose, high strength

TUFF: Light, greenish, grey, clayey, low strength with claystone/siltstone bands

Packer Test Description

TEST #: 14
TEST INTERVAL: 72.9 - 77.9 m
LITHOLOGY: Permian Overburden
INTERPRETED K: 1.64 x 10-3 m/day

TEST #: 13
TEST INTERVAL: 78 - 83 m
LITHOLOGY: Permian Overburden
INTERPRETED K: 1.3 x 10-3 m/day

TEST #: 12
TEST INTERVAL: 89.8 - 94.8 m
LITHOLOGY: AU Seam
INTERPRETED K: 1.6 x 10-3 m/day

TEST #: 11
TEST INTERVAL: 98.8 - 103.8 m
LITHOLOGY: AL Seam
INTERPRETED K: 2.19 x 10-3 m/day

TEST #: 10
TEST INTERVAL: 107.8 - 112.8 m
LITHOLOGY: B Seam
INTERPRETED K: 2.48 x 10-3 m/day

TEST #: 9
TEST INTERVAL: 117 - 122 m
LITHOLOGY: Siltstone Interburden
INTERPRETED K: 3.1 x 10-3 m/day

TEST #: 8
TEST INTERVAL: 123.7 - 128.7 m
LITHOLOGY: C4 / C3 Seam
INTERPRETED K: 1.5 x 10-2 m/day

TEST #: 7
TEST INTERVAL: 131.5 - 134.5 m
LITHOLOGY: C2 Seam
INTERPRETED K: 5.19 x 10-3 m/day

TEST #: 6
TEST INTERVAL: 137.8 - 142.8 m
LITHOLOGY: Sandstone Interburden
INTERPRETED K: 1.62 x 10-3 m/day

TEST #: 5
TEST INTERVAL: 145.5 - 149.5 m
LITHOLOGY: Siltstone Interburden
INTERPRETED K: 2.49 x 10-3 m/day

TEST #: 4
TEST INTERVAL: 150.5 - 155.5 m
LITHOLOGY: D Seam
INTERPRETED K: 3.29 x 10-3 m/day

TEST #: 3
TEST INTERVAL: 159.5 - 164.5 m
LITHOLOGY: E Seam
INTERPRETED K: 1.3 x 10-2 m/day

TEST #: 2
TEST INTERVAL: 165.6 - 169.6 m
LITHOLOGY: F Seam
INTERPRETED K: 1.03 x 10-2 m/day

TEST #: 1
TEST INTERVAL: 172 - 176 m
LITHOLOGY: coarse sandstone
INTERPRETED K: 3.92 x 10-3 m/day

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BOREHOLE LOG

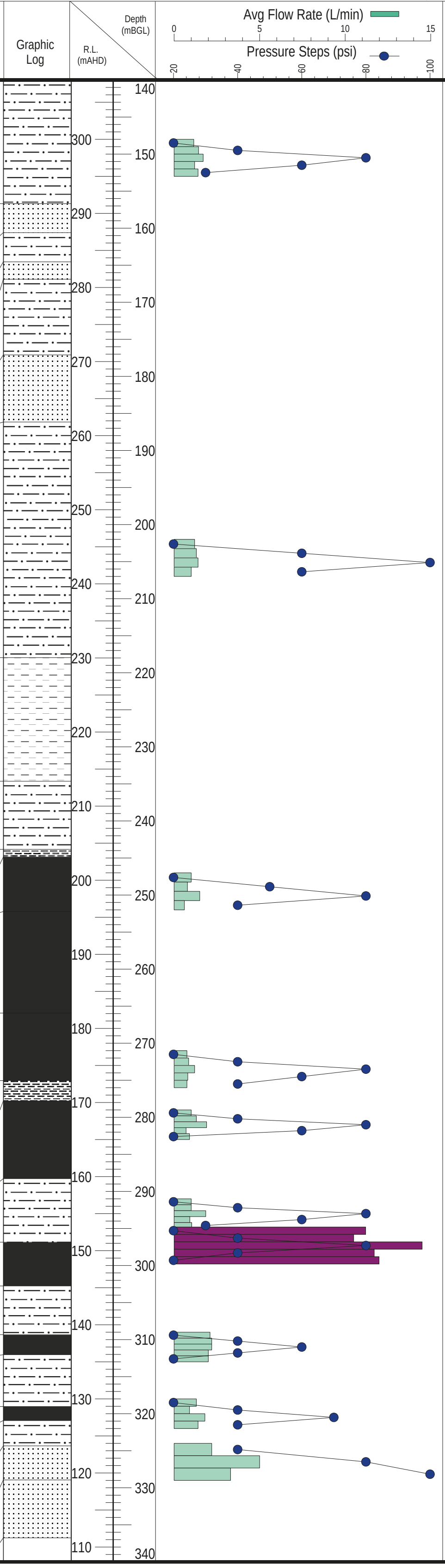
BOREHOLE ID: **MC5043 (Packer Test)** page:1 of 1

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **16th Jul 2013**
LOGGED BY: **t. Womack**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **Rob**
No. OF TEST INTERVALS: **10**
TEST OPERATOR: **H. McCarthy (AGE)**

SITE ID: **M24**
EASTING: **408068 mE**
NORTHING: **7596724 mN**
DATUM: **GDA94 (z55)**
RL: **448 mAHD**
TD: **336.32 mBGL**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	SANDSTONE/SILTSTONE: Fine grained, light, grey, low strength
Betts Creek Beds (Permian)	SANDSTONE: Fine to medium grained, medium, grey, carbonaceous wisps, low strength
	SANDSTONE/SILTSTONE: Very fine grained, light, grey, low strength
	SANDSTONE : Fine to medium grained, light, grey, clay, bands, low strength rock
	SANDSTONE/SILTSTONE: Medium, grey, occasional, siltstone, bands, low strength
	SANDSTONE : Medium grained, light, grey, siltstone bands, low strength rock
	SANDSTONE/SILTSTONE: Fine grained, light, grey, low strength
	SILTSTONE: Medium, grey, thin, sandstone, laminae, low strength rock
	SANDSTONE/SILTSTONE: Very fine grained, light, grey, low strength
A Seam	CARBONACEOUS SILTSTONE: Dark, blackish, grey, very low strength
	COAL: 1-40% bright, AU4 to AU1 seams
	COAL: 1-10% bright, tuff bands, AL4 to AL1 seams
B Seam	COAL: Dull <1% bright, B4 to B1 seams
	CARBONACEOUS SILTSTONE: Dark, blackish, grey, very low strength with bands of coal and sandstone
C Seam	COAL: 1-40% bright, C5 to C4 seams with siltstone bands
	SANDSTONE/SILTSTONE: Medium grained, rare, carbonaceous wisps, low strength
D Seam	COAL: 1-60% bright, D2 / D1 seams
	SANDSTONE/SILTSTONE: Very fine grained, rare, carbonaceous wisps, low strength
	COAL: 1-60% bright, E2 / E1 seams
	SANDSTONE/SILTSTONE: Medium to coarse grained, rare, carbonaceous wisps, low strength
	COAL: 1-60% bright, F seam
	SANDSTONE/SILTSTONE: Fine grained, grey, low strength
	SANDSTONE: Coarse grained, speckled, grey, quartzose, very low strength
	SANDSTONE: Fine to medium grained, light, grey, carbonaceous wisps, medium strength



Packer Test Description

TEST #: 10
TEST INTERVAL: 148 - 153 m
LITHOLOGY: Rewan Formation (SS)
INTERPRETED K: 2.48 x 10-3 m/day

TEST #: 9
TEST INTERVAL: 202 - 207 m
LITHOLOGY: Permian Overburden (SS/ST)
INTERPRETED K: 2.04 x 10-3 m/day

TEST #: 8
TEST INTERVAL: 247 - 252 m
LITHOLOGY: Au2/Au1 Seam
INTERPRETED K: 1.63 x 10-3 m/day

TEST #: 7
TEST INTERVAL: 271 - 276 m
LITHOLOGY: B2/B1 Seam
INTERPRETED K: 1.52 x 10-3
TEST #: 6
TEST INTERVAL: 279 - 283 m
LITHOLOGY: C5 Seam
INTERPRETED K: 2.48 x 10-3 m/day

TEST #: 5
TEST INTERVAL: 291 - 295 m
LITHOLOGY: SS/ST Interburden
INTERPRETED K: 2.43 x 10-3 m/day
TEST #: 4
TEST INTERVAL: 294.8 - 299.8 m
LITHOLOGY: D Seam
INTERPRETED K: 2.13 x 10-2 m/day

TEST #: 3
TEST INTERVAL: 309 - 313 m
LITHOLOGY: E Seam
INTERPRETED K: 4.79 x 10-3 m/day

TEST #: 2
TEST INTERVAL: 318 - 322 m
LITHOLOGY: F Seam
INTERPRETED K: 2.69 x 10-3 m/day
TEST #: 1
TEST INTERVAL: 324 - 329 m
LITHOLOGY: Coarse Sandstone
INTERPRETED K: 5.06 x 10-3 m/day

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BOREHOLE LOG

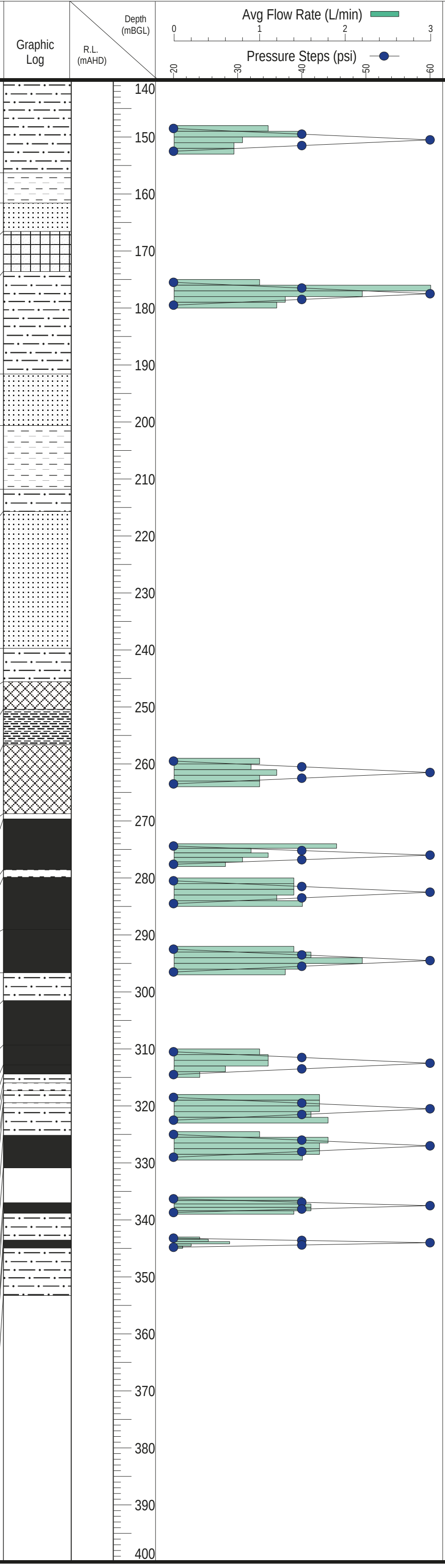
BOREHOLE ID: **MC5044 (Packer Test)** page:1 of 1

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **22nd Jul 2013**
LOGGED BY: **A. Tarr**

DRILLING COMPANY:
DRILLER: **M. Alderman**
No. OF TEST INTERVALS: **11**
TEST OPERATOR: **A. De La Cruz (Macmines)**

SITE ID: **U32**
EASTING: **407746.7 mE**
NORTHING: **7604641.7 mN**
DATUM: **GDA94 (z55)**
RL: **mAHD**
TD: **400 mBGL**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	SANDSTONE/SILTSTONE: Very fine grained, blueish bands, low strength
	SILTSTONE: Light, greenish, grey, sandy
	SANDSTONE: Fine to medium grained, light, greyish, green,lithic, siltstone, bands, low strength
	SANDSTONE/CLAYSTONE: Fine to medium grained, light, greyish, green
	SANDSTONE/SILTSTONE: Fine to medium grained, grey, low strength
	SANDSTONE: Fine to medium grained, grey, low strength
	SILTSTONE: Light, greyish, green, sandstone, bands, medium strength
Betts Creek Beds (Permian)	SANDSTONE/SILTSTONE: Fine to medium grained, grey, low strength
	SANDSTONE: Fine to coarse grained, light, grey, medium strength
	SANDSTONE/SILTSTONE: Fine to medium grained, grey, low strength
	CARBONACEOUS CLAYSTONE: Dark, grey, sandy, bands, medium strength
	CARBONACEOUS SILTSTONE: Dark, grey, sandy, bands, medium strength
	CARBONACEOUS CLAYSTONE: Dark, grey, sandy, coal bands, medium strength
A Seam	SILTSTONE: Medium, grey, silty, clayey, laminae, medium strength
	COAL: 1-90% bright, AU4 to AU1 seams
	CLAYSTONE: Dark, grey, tuff bands, low strength
	COAL: 1-10% bright, tuff bands, AL4 to AL1 seams
B Seam	COAL: <1-90% bright, tuff bands, B4 to B1 seams
	SANDSTONE/SILTSTONE: Fine to coarse grained, light, grey, medium strength
C Seam	COAL: 1-40% bright, C5 to C4 seams with siltstone and tuff bands
Betts Creek Beds (Permian)	COAL: Stony with tuff and carbonaceous claystone layers
	COAL: 1-90% bright, tuff bands, C3 seam
	SANDSTONE/SILTSTONE: Fine to medium grained, light, grey, medium strength
	CLAYSTONE: Dark, grey, coal bands, low strength
	SANDSTONE/SILTSTONE: Fine to medium grained, light, grey, medium strength
	CLAYSTONE: Dark, grey, silty near top of unit, sideritic coaly wisps, low strength
	SANDSTONE/SILTSTONE: Fine to medium grained, light, grey, carbonaceous claystone bands, medium strength
	COAL: 1-60% bright, D2 / D1 seams
	SILTSTONE/Sandstone: Light to dark, grey with fine to medium grained sandstone bands
	COAL: 1-90% bright, E seam
	SANDSTONE/SILTSTONE: Fine to medium grained, grey, carbonaceous siltstone bands
	COAL: 1-90% bright, tuff bands, F seam
	SANDSTONE/SILTSTONE: Fine to medium grained, quartzose bands, grey



Packer Test Description

TEST #: 11
TEST INTERVAL: 148 - 153 m
LITHOLOGY: Rewan Overburden
INTERPRETED K: 5.0 x 10-3 m/day

TEST #: 10
TEST INTERVAL: 175 - 180 m
LITHOLOGY: Rewan Overburden
INTERPRETED K: 8.75 x 10-3 m/day

TEST #: 9
TEST INTERVAL: 259 - 264 m
LITHOLOGY: Permian Overburden
INTERPRETED K: 5.58 x 10-3 m/day

TEST #: 8
TEST INTERVAL: 274 - 278 m
LITHOLOGY: AU1 - Seam
INTERPRETED K: 5.37 x 10-3 m/day

TEST #: 7
TEST INTERVAL: 280 - 285 m
LITHOLOGY: AL- Seam
INTERPRETED K: 7.54 x 10-3 m/day

TEST #: 6
TEST INTERVAL: 292 - 297 m
LITHOLOGY: B-Seam
INTERPRETED K: 8.62 x 10-3 m/day

TEST #: 5
TEST INTERVAL: 310 - 315 m
LITHOLOGY: C-Seam
INTERPRETED K: 4.04 x 10-3 m/day

TEST #: 4
TEST INTERVAL: 318 - 323 m
LITHOLOGY: Interburden - SS/ST
INTERPRETED K: 9.31 x 10-3 m/day

TEST #: 3
TEST INTERVAL: 324.5 - 329.5 m
LITHOLOGY: D2-Seam
INTERPRETED K: 8.27 x 10-3 m/day

TEST #: 2
TEST INTERVAL: 336 - 339 m
LITHOLOGY: E Seam
INTERPRETED K: 8.32 x 10-3 m/day

TEST #: 1
TEST INTERVAL: 343 - 345 m
LITHOLOGY: F Seam
INTERPRETED K: 1.5 x 10-3 m/day

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BOREHOLE LOG

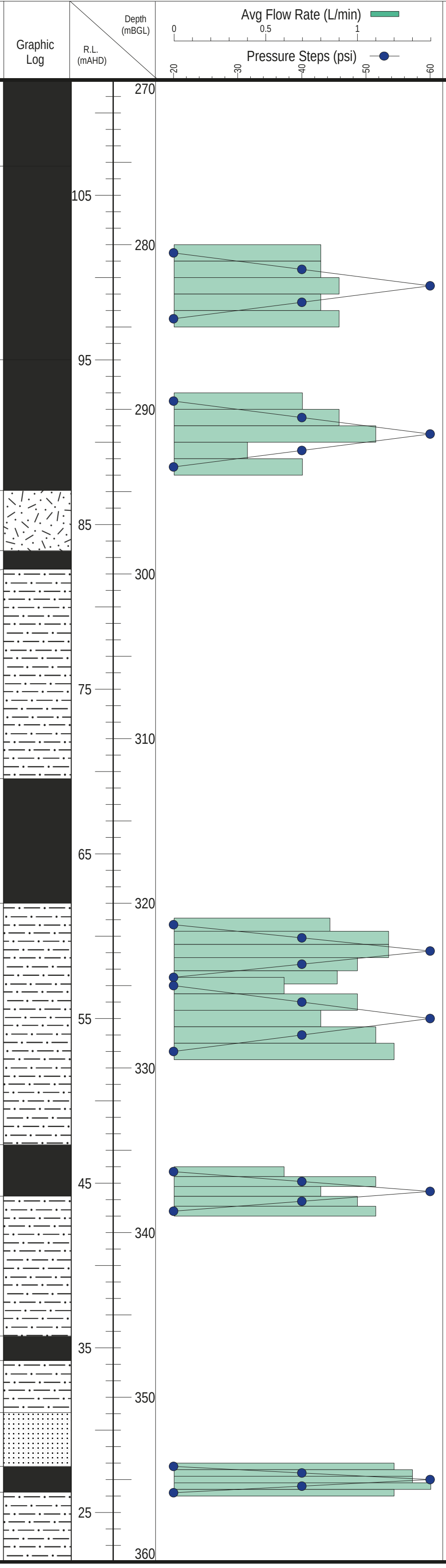
BOREHOLE ID: **MC5046 (Packer Test)** page:1 of 1

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **28th Jul 2013**
LOGGED BY: **H. Donovan / A. Tarr**

DRILLING COMPANY:
DRILLER:
No. OF TEST INTERVALS: **6**
TEST OPERATOR: **A. De La Cruz (Macmines)**

SITE ID: **G15**
EASTING: **410892.5 mE**
NORTHING: **7589248.9 mN**
DATUM: **GDA94 (z55)**
RL: **382 mAHD**
TD: **369.7 mBGL**

Stratigraphic Interpretation	Soil or Rock Field Material Description
A Seam	COAL: 1-90% bright, AU4 to AU1 seams
	COAL: Dull <1% bright, tuff bands, AL4 to AL1 seams
B Seam	COAL: Dull <1% bright, tuff bands, B3 to B1 seams
	TUFF: Contains stoney coal and carbonaceous claystone bands
	COAL: Dull <1% bright, C5 seam
Betts Creek Beds (Permian)	SANDSTONE/SILTSTONE: Fine to coarse grained, light, grey, quartzose bands, medium strength
C Seam	COAL: Dull <1% bright, tuff bands, C4 to C2 seams
Betts Creek Beds (Permian)	SANDSTONE/SILTSTONE: Fine to coarse grained, light to dark grey, quartzose bands, medium strength
D Seam	COAL: 1-60% bright, tuff bands, D2 / D1 seams
	SANDSTONE/SILTSTONE: Fine to coarse grained, light to dark grey, tuff and carbonaceous siltstone bands, medium strength
	COAL: 1-90% bright, claystone bands, E2 / E1 seams
	SANDSTONE/SILTSTONE: Very fine to medium grained, grey, carbonaceous wisps, medium strength
	SANDSTONE: Coarse grained, medium, grey, bands, medium strength
	COAL: 1-90% bright, tuff bands, F seam
	SANDSTONE/SILTSTONE: Very fine to medium grained, grey, carbonaceous wisps, medium strength



Packer Test Description

TEST #: 6
TEST INTERVAL: 280 - 285 m
LITHOLOGY: AL- Seam
INTERPRETED K: 2.76 x 10-3 m/day

TEST #: 5
TEST INTERVAL: 289 - 294 m
LITHOLOGY: B2-Interburden
INTERPRETED K: 2.37 x 10-3 m/day

TEST #: 4
TEST INTERVAL: 320.9 - 324.9 m
LITHOLOGY: Interburden - SS/ST
INTERPRETED K: 4.14 x 10-3 m/day

TEST #: 3
TEST INTERVAL: 324.5 - 329.5 m
LITHOLOGY: D2-Seam
INTERPRETED K: 7.5 x 10-3 m/day

TEST #: 2
TEST INTERVAL: 336 - 339 m
LITHOLOGY: E-Seam
INTERPRETED K: 7.37 x 10-3 m/day

TEST #: 1
TEST INTERVAL: 343 - 345 m
LITHOLOGY: F-Seam
INTERPRETED K: 1.05 x 10-2 m/day

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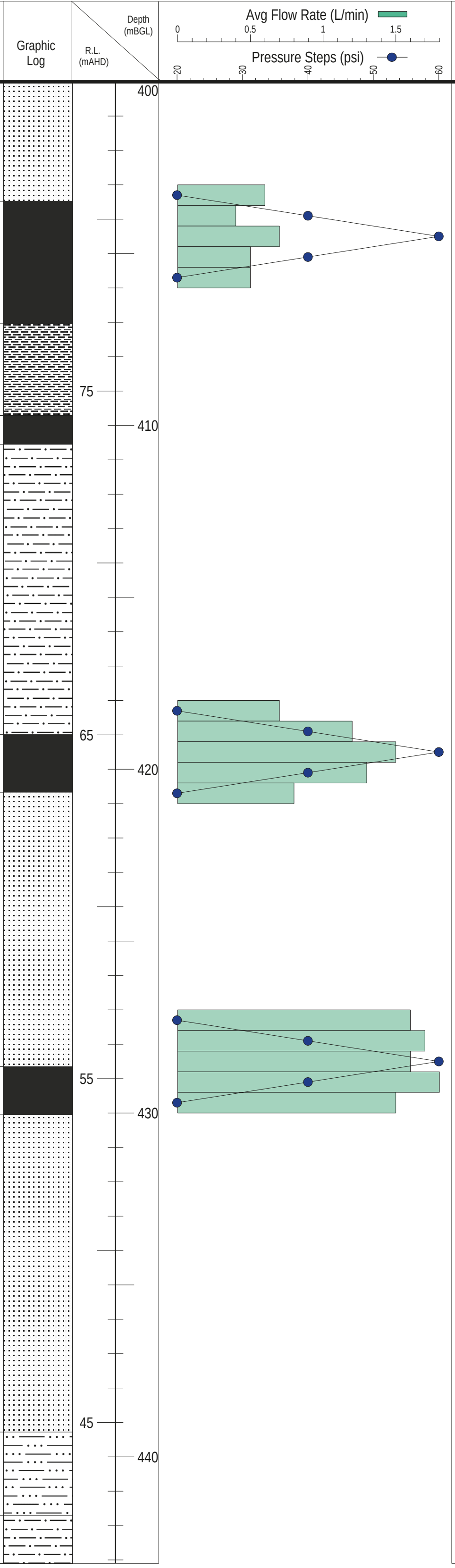
BOREHOLE LOG

BOREHOLE ID: **MC5049 (Packer Test)** page:1 of 1

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **14th Sep 2013**
LOGGED BY: **A. Tarr**

DRILLING COMPANY:
DRILLER: **M. Alderman**
No. OF TEST INTERVALS: **3**
TEST OPERATOR: **A. De La Cruz (Macmines)**

SITE ID: **I20**
EASTING: **408318.8 mE**
NORTHING: **7592431.8 mN**
DATUM: **GDA94 (z55)**
RL: **484 mAHD**
TD: **443.1 mBGL**



Stratigraphic Interpretation	Soil or Rock Field Material Description
Betts Creek Beds (Permian)	SANDSTONE: Fine to medium, grey, conglomerate bands
D Seam	COAL: 1-90% bright, tuff bands, D2 seam
	CARBONACEOUS SILTSTONE: Contains siltstone and sandstone bands, low strength
	COAL: <1-10% bright, tuff bands, D1 seam
Betts Creek Beds (Permian)	SANDSTONE/SILTSTONE: Fine to coarse grained, light grey, medium strength
E Seam	COAL: <1-90% bright, tuff bands, E2 / E1 seam
Betts Creek Beds (Permian)	SANDSTONE: Fine to coarse grained, medium, grey, siltstone and conglomerate bands, medium strength
F Seam	COAL: 1-60% bright, tuff bands, F seam
Betts Creek Beds (Permian)	SANDSTONE: Fine to coarse grained, medium, grey, conglomerate bands, medium strength
	CLAYSTONE/SANDSTONE: Dark, brownish to blueish, grey, minor, carbonaceous wisps, fine grained, medium strength
	SANDSTONE/SILTSTONE: Very fine to fine grained, grey, medium strength

Packer Test Description

TEST #: 3
TEST INTERVAL: 403 - 407 m
LITHOLOGY: D2-Seam
INTERPRETED K: 1.7 x 10-3 m/day

TEST #: 2
TEST INTERVAL: 418 - 421 m
LITHOLOGY: E-Seam
INTERPRETED K: 3.38 x 10-3 m/day

TEST #: 1
TEST INTERVAL: 427 - 430 m
LITHOLOGY: F-Seam
INTERPRETED K: 5.22 x 10-3 m/day

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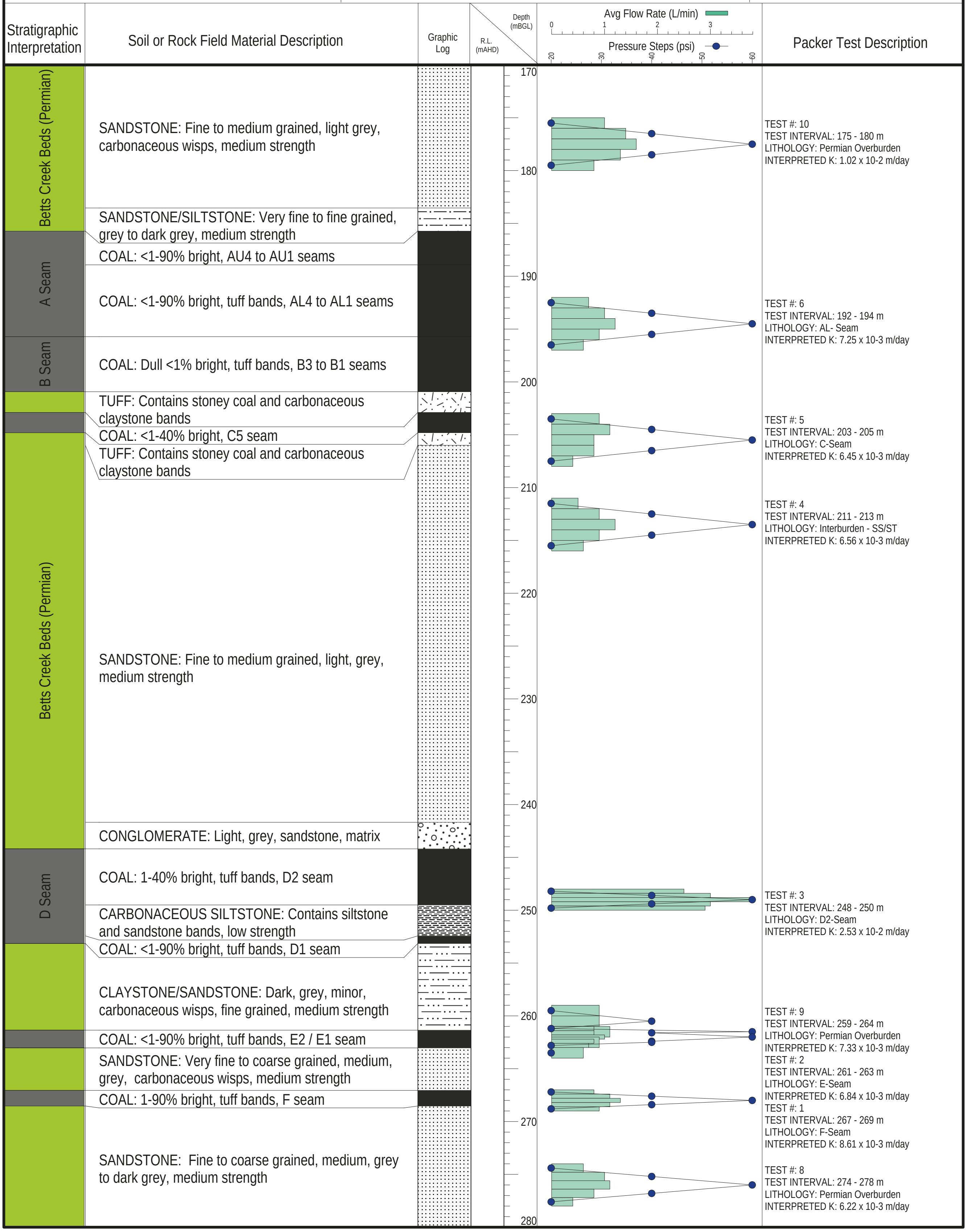
BOREHOLE LOG

BOREHOLE ID: **MC5051 (Packer Test)** page:1 of 1

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **4th Oct 2013**
LOGGED BY: **A. Tarr**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **Rob / Scott**
No. OF TEST INTERVALS: **10**
TEST OPERATOR: **A. De La Cruz (Macmines)**

SITE ID: **J19**
EASTING: **409982 mE**
NORTHING: **7592604 mN**
DATUM: **GDA94 (z55)**
RL: **mAHD**
TD: **281.88 mBGL**



SANDSTONE: Fine to medium grained, light grey, carbonaceous wisps, medium strength

SANDSTONE/SILTSTONE: Very fine to fine grained, grey to dark grey, medium strength

COAL: <1-90% bright, AU4 to AU1 seams

COAL: <1-90% bright, tuff bands, AL4 to AL1 seams

COAL: Dull <1% bright, tuff bands, B3 to B1 seams

TUFF: Contains stoney coal and carbonaceous claystone bands

COAL: <1-40% bright, C5 seam

TUFF: Contains stoney coal and carbonaceous claystone bands

SANDSTONE: Fine to medium grained, light, grey, medium strength

CONGLOMERATE: Light, grey, sandstone, matrix

COAL: 1-40% bright, tuff bands, D2 seam

CARBONACEOUS SILTSTONE: Contains siltstone and sandstone bands, low strength

COAL: <1-90% bright, tuff bands, D1 seam

CLAYSTONE/SANDSTONE: Dark, grey, minor, carbonaceous wisps, fine grained, medium strength

COAL: <1-90% bright, tuff bands, E2 / E1 seam

SANDSTONE: Very fine to coarse grained, medium, grey, carbonaceous wisps, medium strength

COAL: 1-90% bright, tuff bands, F seam

SANDSTONE: Fine to coarse grained, medium, grey to dark grey, medium strength

TEST #: 10
TEST INTERVAL: 175 - 180 m
LITHOLOGY: Permian Overburden
INTERPRETED K: 1.02 x 10-2 m/day

TEST #: 6
TEST INTERVAL: 192 - 194 m
LITHOLOGY: AL- Seam
INTERPRETED K: 7.25 x 10-3 m/day

TEST #: 5
TEST INTERVAL: 203 - 205 m
LITHOLOGY: C-Seam
INTERPRETED K: 6.45 x 10-3 m/day

TEST #: 4
TEST INTERVAL: 211 - 213 m
LITHOLOGY: Interburden - SS/ST
INTERPRETED K: 6.56 x 10-3 m/day

TEST #: 3
TEST INTERVAL: 248 - 250 m
LITHOLOGY: D2-Seam
INTERPRETED K: 2.53 x 10-2 m/day

TEST #: 9
TEST INTERVAL: 259 - 264 m
LITHOLOGY: Permian Overburden
INTERPRETED K: 7.33 x 10-3 m/day
TEST #: 2
TEST INTERVAL: 261 - 263 m
LITHOLOGY: E-Seam
INTERPRETED K: 6.84 x 10-3 m/day
TEST #: 1
TEST INTERVAL: 267 - 269 m
LITHOLOGY: F-Seam
INTERPRETED K: 8.61 x 10-3 m/day

TEST #: 8
TEST INTERVAL: 274 - 278 m
LITHOLOGY: Permian Overburden
INTERPRETED K: 6.22 x 10-3 m/day

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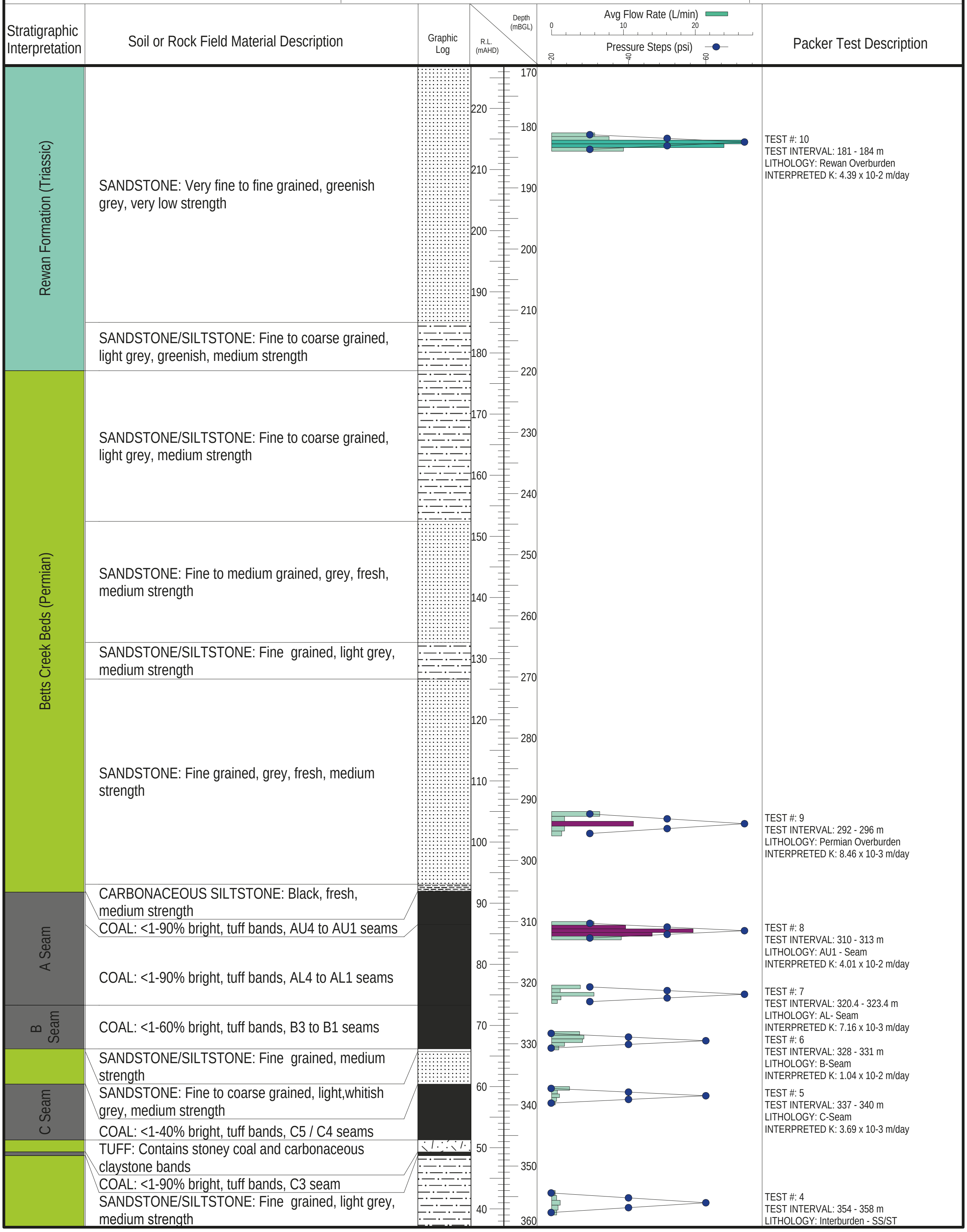
BOREHOLE LOG

BOREHOLE ID: **MC5052 (Packer Test)** page:1 of 1

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **17th Oct 2013**
LOGGED BY: **A. De La Cruz**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **A. Moore**
No. OF TEST INTERVALS: **11**
TEST OPERATOR: **A. De La Cruz (Macmines)**

SITE ID: **U30**
EASTING: **409479 mE**
NORTHING: **7603797 mN**
DATUM: **GDA94 (z55)**
RL: **397 mAHD**
TD: **402.2 mBGL**



Soil or Rock Field Material Description
SANDSTONE: Very fine to fine grained, greenish grey, very low strength
SANDSTONE/SILTSTONE: Fine to coarse grained, light grey, greenish, medium strength
SANDSTONE/SILTSTONE: Fine to coarse grained, light grey, medium strength
SANDSTONE: Fine to medium grained, grey, fresh, medium strength
SANDSTONE/SILTSTONE: Fine grained, light grey, medium strength
SANDSTONE: Fine grained, grey, fresh, medium strength
CARBONACEOUS SILTSTONE: Black, fresh, medium strength
COAL: <1-90% bright, tuff bands, AU4 to AU1 seams
COAL: <1-90% bright, tuff bands, AL4 to AL1 seams
COAL: <1-60% bright, tuff bands, B3 to B1 seams
SANDSTONE/SILTSTONE: Fine grained, medium strength
SANDSTONE: Fine to coarse grained, light,whitish grey, medium strength
COAL: <1-40% bright, tuff bands, C5 / C4 seams
TUFF: Contains stoney coal and carbonaceous claystone bands
COAL: <1-90% bright, tuff bands, C3 seam
SANDSTONE/SILTSTONE: Fine grained, light grey, medium strength

Packer Test Description

TEST #: 10
TEST INTERVAL: 181 - 184 m
LITHOLOGY: Rewan Overburden
INTERPRETED K: 4.39 x 10-2 m/day

TEST #: 9
TEST INTERVAL: 292 - 296 m
LITHOLOGY: Permian Overburden
INTERPRETED K: 8.46 x 10-3 m/day

TEST #: 8
TEST INTERVAL: 310 - 313 m
LITHOLOGY: AU1 - Seam
INTERPRETED K: 4.01 x 10-2 m/day

TEST #: 7
TEST INTERVAL: 320.4 - 323.4 m
LITHOLOGY: AL- Seam
INTERPRETED K: 7.16 x 10-3 m/day

TEST #: 6
TEST INTERVAL: 328 - 331 m
LITHOLOGY: B-Seam
INTERPRETED K: 1.04 x 10-2 m/day

TEST #: 5
TEST INTERVAL: 337 - 340 m
LITHOLOGY: C-Seam
INTERPRETED K: 3.69 x 10-3 m/day

TEST #: 4
TEST INTERVAL: 354 - 358 m
LITHOLOGY: Interburden - SS/ST

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BOREHOLE LOG

BOREHOLE ID: **VWP1 (MC5026)** page:1 of 6

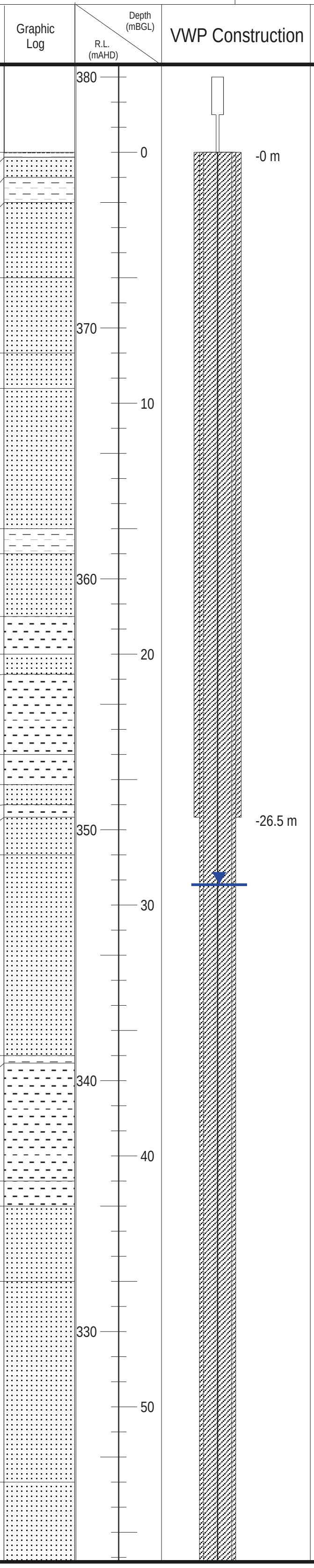
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **9/03/2013**
LOGGED BY: **B.Walker**

DRILLING COMPANY: **Eastern Drilling**
DRILLER: **Zipper**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **Eastern 1**

EASTING: **410643 mE**
NORTHING: **7590108 mN**
DATUM: **GDA94Z55**
RL: **377 mAHD**
TD: **350.77 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SOIL: Brown, extremely weathered.
	SANDSTONE: Very fine grained, light, brown, extremely weathered
	SILTSTONE: Red, extremely weathered.
	SANDSTONE: Very fine to fine grained, mottled, creamy, red, silty in part, extremely weathered.
	SANDSTONE: Very fine grained, light, brownish, cream, extremely weathered.
	SANDSTONE: Very fine grained, light, greyish, cream, extremely weathered.
	SANDSTONE: Very fine to fine grained, light, creamy, brown, rare carbonaceous fragments, extremely weathered.
	SILTSTONE: Brown, sandy in part, extremely weathered.
	SANDSTONE: Very fine to fine grained, light, greyish, brown, extremely weathered.
	CLAYSTONE: Dark, red, extremely weathered.
	SANDSTONE: Very fine grained, light, creamy, brown, extremely weathered.
	CLAYSTONE: Dark, red, extremely weathered.
	CLAYSTONE: Purple, extremely weathered.
	SANDSTONE: Very fine grained, clayey in part, extremely weathered.
	CLAYSTONE: Mottled, greyish, red, extremely weathered.
	SANDSTONE: Very fine grained, light, brown, distinctly weathered.
	SANDSTONE: Fine to coarse grained, pink, distinctly weathered.
	SILTSTONE: Light, brown, clayey in part, distinctly weathered.
	CLAYSTONE: Dark, red, distinctly weathered.
	CLAYSTONE: Pink, distinctly weathered.
	SANDSTONE: Very fine grained, light, brown, distinctly weathered.
	SANDSTONE: Fine to medium grained, buff, distinctly weathered.
	SANDSTONE: Fine to coarse grained, pink, distinctly weathered. Base of tertiary



VWP Description

152 mm PCD from 0 to 26.5 m

125mm PVC to 26.5 m

123 mm PCD from 26.5 m to 220.6 m

96 mm HQ core from 220.6 m to 350.7 m

SWL during construction (open hole): 29.19 mBGL on the 22nd March 2013

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BOREHOLE LOG

BOREHOLE ID: **VWP1 (MC5026)** page:2 of 6

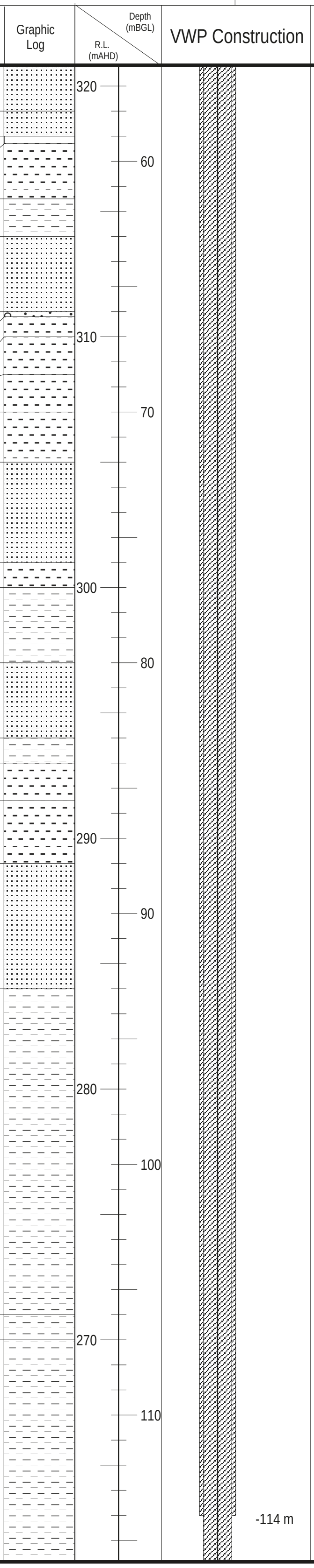
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **9/03/2013**
LOGGED BY: **B.Walker**

DRILLING COMPANY: **Eastern Drilling**
DRILLER: **Zipper**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **Eastern 1**

EASTING: **410643 mE**
NORTHING: **7590108 mN**
DATUM: **GDA94Z55**
RL: **377 mAHD**
TD: **350.77 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	SANDSTONE: Fine to coarse grained, light, brown, distinctly weathered.
	SIDERITE: Dark, brown, distinctly weathered.
	CLAYSTONE: Pink, distinctly weathered.
	SILTSTONE: Light, brownish, pink, distinctly weathered.
	SANDSTONE: Very fine grained, buff, slightly weathered.
	CONGLOMERATE: Mottled, slightly weathered.
	CLAYSTONE: Creamy, brown, slightly weathered. Base of weathering
	CLAYSTONE: Dark, brown, fresh.
	CLAYSTONE: Mottled, bluish, brown.
	CLAYSTONE: Greyish, blue.
	SANDSTONE: Very fine grained, grey, silty near base of unit.
	CLAYSTONE: Purplish, brown.
	SILTSTONE: Greyish, green, clayey in part.
	SANDSTONE: Very fine grained, grey.
	SILTSTONE: Grey.
	CLAYSTONE: Brownish, grey.
	CLAYSTONE: Grey.
	SANDSTONE: Fine grained, light, greenish, grey, silty in part.
	SILTSTONE: Greyish, green, clay in part.
	SILTSTONE: Dark, brownish, green.
	SILTSTONE: Green, sandstone in part.



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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **VWP1 (MC5026)** page:3 of 6

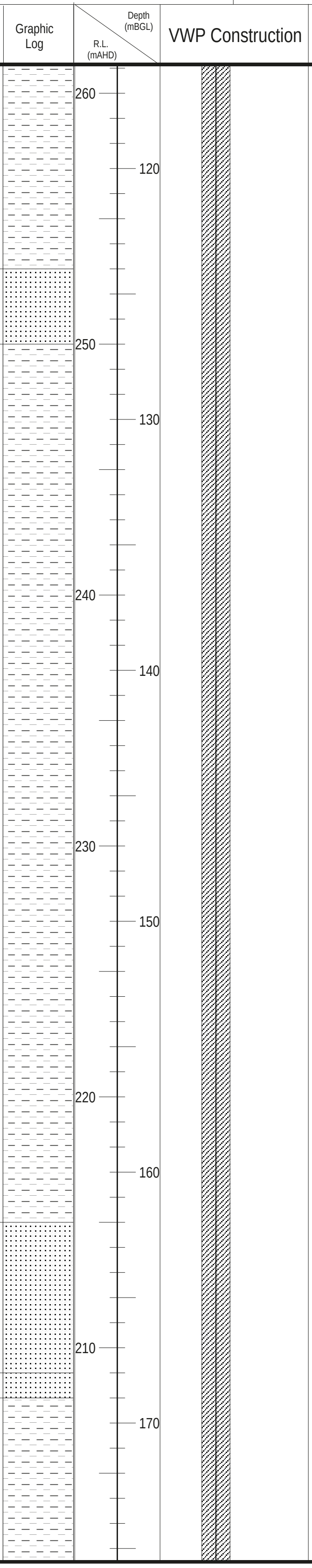
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **9/03/2013**
LOGGED BY: **B.Walker**

DRILLING COMPANY: **Eastern Drilling**
DRILLER: **Zipper**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **Eastern 1**

EASTING: **410643 mE**
NORTHING: **7590108 mN**
DATUM: **GDA94Z55**
RL: **377 mAHD**
TD: **350.77 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description	VWP Description
Rewan Formation (Triassic)		
	SANDSTONE: Greyish, green, siltstone in part.	
	SILTSTONE: Greyish, green, claystone in part.	
	SANDSTONE: Very fine grained, light to medium, bluish, grey.	
	SANDSTONE: Fine to medium grained, light to medium, bluish, grey, lithic.	



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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **VWP1 (MC5026)** page:4 of 6

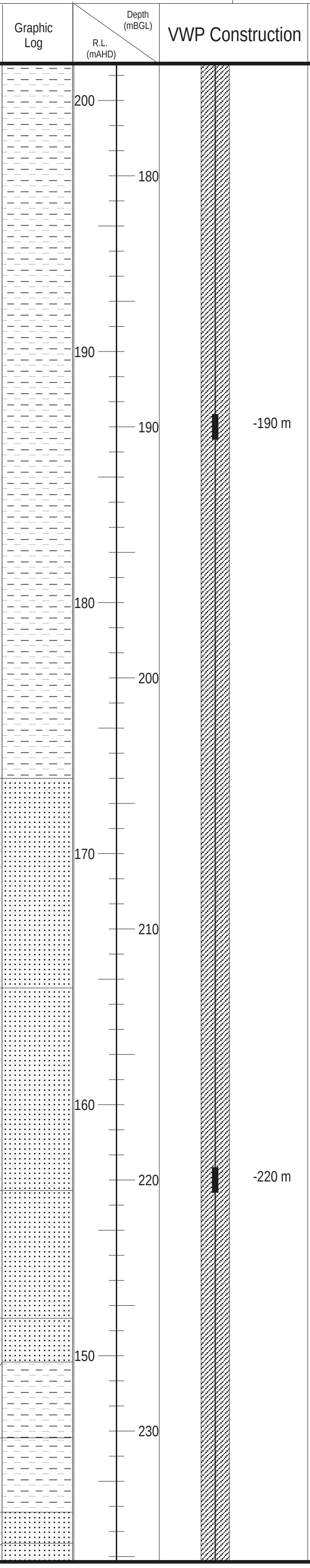
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **9/03/2013**
LOGGED BY: **B.Walker**

DRILLING COMPANY: **Eastern Drilling**
DRILLER: **Zipper**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **Eastern 1**

EASTING: **410643 mE**
NORTHING: **7590108 mN**
DATUM: **GDA94Z55**
RL: **377 mAHD**
TD: **350.77 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	SILTSTONE: Medium, grey, minor sandy in part. Base of Triassic.
Betts Creek Beds (Permian)	SANDSTONE: Fine to medium grained, light to medium, grey, lithic.
	SANDSTONE: Fine to medium grained, light to medium, grey, lithic.
	SANDSTONE: Fine to medium grained, light, grey, low strength rock, massive/absent bedding.
	SANDSTONE (70%) / SILTSTONE (30%): 70% very fine to fine grained, light, grey, occasional, sideritic, bands, low strength rock, very thinly bedded(20-60mm).
	SILTSTONE: Grey, occasional, sandy, bands, throughout, low strength rock, very thinly bedded(20-60mm).
	SILTSTONE: Grey, sandy, bands, near top and base of unit, low strength rock, thinly bedded(60-200mm).
	SANDSTONE: Very fine grained, grey, silty, in part, low strength rock, thinly bedded(60-200mm).



VWP Description

Sensor 1. Serial no. 12-8935. Depth 190 mbGL. Lithology Rewan Formation.

Sensor 2. Serial no. 12-8927. Depth 220 mbGL. Lithology Sandstone Overburden.

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BOREHOLE LOG

BOREHOLE ID: **VWP1 (MC5026)** page:5 of 6

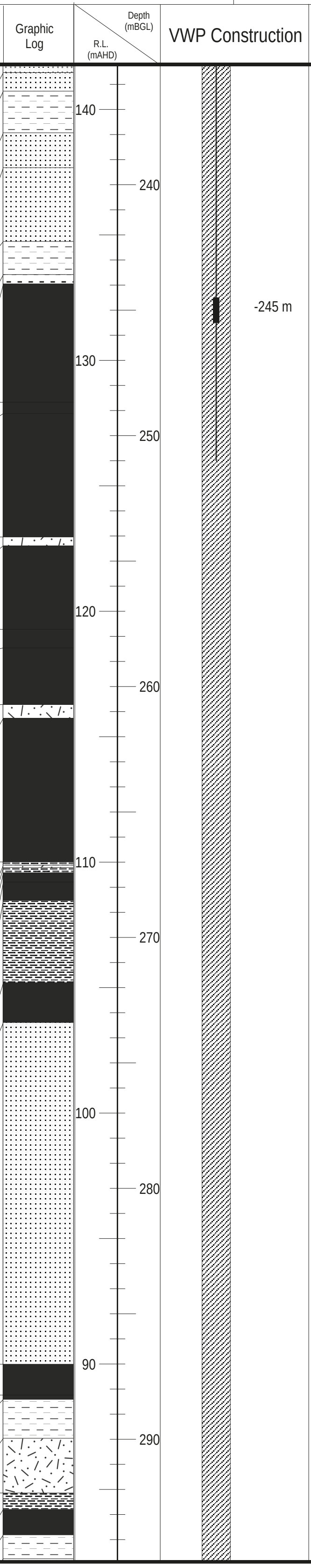
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **9/03/2013**
LOGGED BY: **B.Walker**

DRILLING COMPANY: **Eastern Drilling**
DRILLER: **Zipper**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **Eastern 1**

EASTING: **410643 mE**
NORTHING: **7590108 mN**
DATUM: **GDA94Z55**
RL: **377 mAHD**
TD: **350.77 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description	VWP Description
	SANDSTONE: Fine to coarse grained, light, grey, low strength rock, medium bedded(200-600mm).	
	SANDSTONE: Very fine grained, grey, silty, in part, low strength rock.	
	SILTSTONE: D, greyish, rare, sandy, bands, near base of unit, low strength rock, medium bedded(200-600mm).	
	SANDSTONE: Fine to coarse grained, light, grey, rare, carbonaceous wisps, low strength rock, thickly bedded(600-2000mm).	
	SANDSTONE (50%) / SILTSTONE (50%): 50% very fine grained, grey, low strength rock, thinly bedded(60-200mm).	
A Seam	SILTSTONE: Dark, grey, carbonaceous, in part, very low strength rock, thinly bedded(60-200mm).	
	CLAYSTONE: Grey, buff, carbonaceous in part, very low strength rock, thinly bedded(60-200mm).	Sensor 3. Serial no. 12-8925. Depth 245 mbGL. Lithology A Seam.
	COAL: Black, minor carbonaceous claystone, tuff, and siderite. AU3 / AU2 / AU1 Seams	
	COAL: Black, significant tuff in sample	
	COAL: Black, minor carbonaceous clayston and tuff. AL5 / AL4 Seams	
	TUFF: Buff, very low strength rock, minor coal and carbonaceous claystone.	
	COAL: Black, minor carbonaceous clayston, tuff, and siderite. AL3 / AL2 Seams	
	COAL: Black, minor carbonaceous clayston, tuff, and siderite.	
	COAL: Black, minor carbonaceous clayston, tuff, and siderite. AL1 Seam	
	TUFF: Light, brownish, buff, carbonaceous, fragments, near top of unit, extremely low strength rock.	
B Seam	COAL: Black, minor carbonaceous clayston, tuff, and siderite. B3 / B1 Seams	
	CARBONACEOUS CLAYSTONE: Dark, brownish, black, coaly, in part, very low strength rock.	
	TUFF: Carbonaceous, bands, near middle of unit, very low strength rock.	
	CARBONACEOUS CLAYSTONE: Very low strength rock.	
	COAL: Stony, minor tuff and claystone.	
	COAL: Dull <1% bright, stony. B1 Seam	
	CARBONACEOUS CLAYSTONE: Dark, greyish, black, tuffaceous, near middle of unit, very low strength rock. Coal and tuff throughout	
	COAL: Black, dull, minor carbonaceous claystone and tuff. C5 Seam	
Betts Creek Beds (Permian)	SANDSTONE: Fine to coarse grained, light, grey, rare, conglomeratic, bands, near top of unit, low strength rock.	
	COAL: Stony, minor tuff and claystone.	
	COAL: 1-10% bright. C4 Seam	
	CARBONACEOUS CLAYSTONE: Dark, brownish, black, very low strength rock, minor tuff and siltstone.	
	TUFF: Brownish, buff, extremely low strength rock.	
	CARBONACEOUS CLAYSTONE: Dark, greyish, black, occasional, claystone, bands, very low strength rock.	
	COAL: Stony. C3 Seam	



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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **VWP1 (MC5026)** page:6 of 6

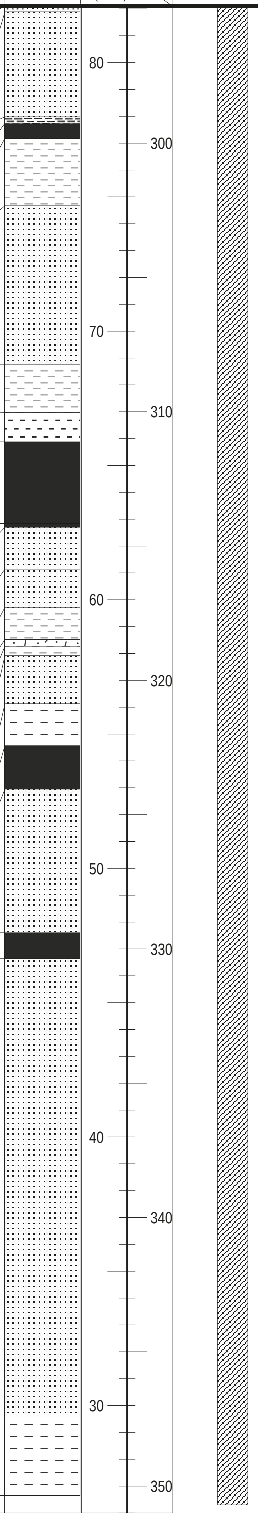
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **9/03/2013**
LOGGED BY: **B.Walker**

DRILLING COMPANY: **Eastern Drilling**
DRILLER: **Zipper**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **Eastern 1**

EASTING: **410643 mE**
NORTHING: **7590108 mN**
DATUM: **GDA94Z55**
RL: **377 mAHD**
TD: **350.77 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description	VWP Description
Betts Creek Beds (Permian)	SILTSTONE: Grey, low strength rock.	
	SANDSTONE: Very fine to fine grained, light, grey, silty, wisps, rare coaly bands near base of unit, low strength rock, siderite at base.	
	SANDSTONE: Fine to coarse grained, light, grey, coaly, wisps, throughout, low strength rock.	
	CARBONACEOUS CLAYSTONE: Dark, greyish, black, very low strength rock.	
	COAL: Stony. C2 Seam	
	SILTSTONE: Grey, rare coaly bands near top of unit, occasional sandstone bands throughout, very low strength rock.	
	SANDSTONE: Fine to medium grained, grey, occasional, silty, bands, throughout, low strength rock.	
	SILTSTONE: Grey, occasional, sandy, bands, carbonaceous near base of unit, very low strength rock.	
	CLAYSTONE: Grey, tuffaceous, in part, very low strength rock.	
D Seam	COAL: Black, carbonaceous claystone splitting plies. D2 / D1 Seam	
Betts Creek Beds (Permian)	COAL: Stony, significant siderite.	
	SANDSTONE: Very fine to fine grained, light, greyish, grey, as, silty, bands, near top of unit, low strength rock, siderite at base.	
	SANDSTONE: Very fine grained, grey, occasional, silty, phases, low strength rock.	
	SILTSTONE: Grey, clayey, near base of unit, low strength rock.	
	TUFF: Very low strength rock, siderite at base.	
	SILTSTONE: Carbonaceous, bands, near top of unit, low strength rock, thin(<5 cm) sandstone at top of unit.	
	SANDSTONE: Fine to medium grained, grey, coarser, near top of unit, low strength rock, very thinly bedded(20-60mm).	
	SILTSTONE: Dark, grey, low strength rock, thickly laminated(6-20mm).	
E Seam	COAL: Black, minor carbonaceous claystone and tuff. E2 / E1 Seams	
	SANDSTONE: Fine to coarse grained, light, grey, low strength rock, medium bedded(200-600mm).	
	COAL: 40-60% bright, minor tuff, carbonaceous claystone at base. F Seam	
Betts Creek Beds (Permian)	SANDSTONE: Fine to coarse grained, light, grey, rare carbonaceous wisps, coarser near base of unit, quartzose, low strength rock.	
	SILTSTONE: Grey, occasional sandy phases, low strength	BOH: 350.7 m



-350.7 m

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **VWP2 (MC5024)** page:1 of 5

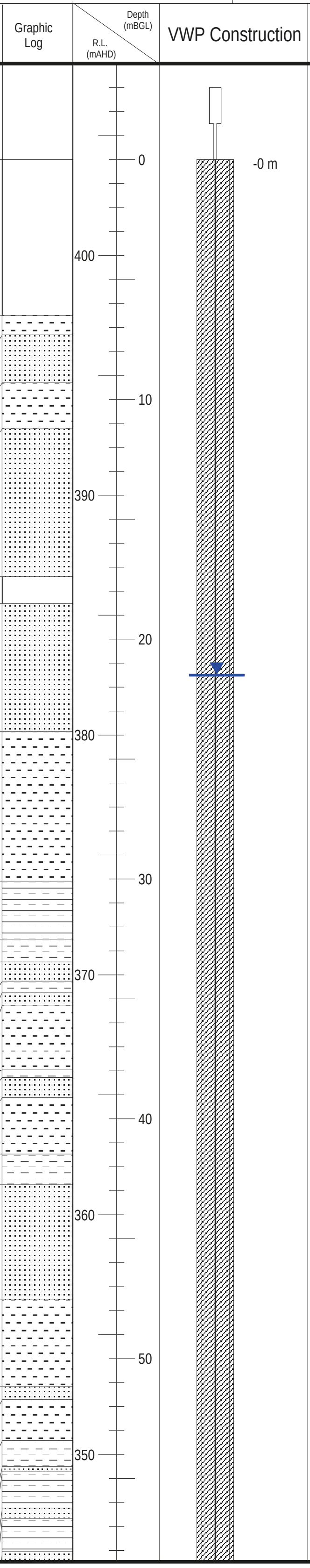
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **21/03/2013**
LOGGED BY: **W.Han**

DRILLING COMPANY: **Eastern Drilling**
DRILLER: **D.Huth**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR09**

EASTING: **408639 mE**
NORTHING: **7594209 mN**
DATUM: **GDA94Z55**
RL: **404 mAHD**
TD: **306.45 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	NO RECOVERY:
	CLAYSTONE (60%) / SANDSTONE (40%): pinkish, yellow, claystone, very low strength rock with pinkish, yellow, siltstone, very low strength rock.
	SANDSTONE: Fine to medium grained, orangy, pink, quartzose, very low strength rock.
	CLAYSTONE: Medium to dark, red, very low strength rock, massive/absent bedding.
	SANDSTONE: Fine to coarse grained, reddish, purple, lithic, very low strength rock,
	NO RECOVERY:
	SANDSTONE: Fine to coarse grained, pinkish, orange, quartzose, very low strength rock, thickly bedded(600-2000mm), broken core.
	CLAYSTONE: Medium to dark, orange, massive/absent bedding.
	MUDSTONE: Medium to dark, red, very low strength rock, thickly bedded(600-2000mm).
	SILTSTONE: Creamy, red, abundant, sandy, bands, very low strength rock.
	SANDSTONE: Very fine to fine grained, purplish, cream, thickly laminated(6-20mm).
	SILTSTONE: Variegated, purplish, cream.
	SANDSTONE: Fine grained, creamy, orange.
	CLAYSTONE: Dark, red, very low strength rock, medium bedded(200-600mm).
	SILTSTONE: Medium, reddish, brown, very low strength rock.
	SANDSTONE: Fine grained, light, grey, lithic.
	CLAYSTONE: Dark, reddish, brown, silty, in part, very low strength rock.
	SILTSTONE: Medium, reddish, brown, clayey, in part, very low strength rock.
	SANDSTONE (50%) / CLAYSTONE (50%): Very fine grained, light to medium, grey, and dark grey claystone, very low strength rock,
	CLAYSTONE: Dark, reddish, brown, to light greyish red, sandy phases, very low strength rock.
	SANDSTONE: Very fine to fine grained, light, greenish, grey, abundant silty, bands, very low strength rock, thinly bedded(60-200mm).
	CLAYSTONE: Mottled, brownish, grey, very low strength rock, massive/absent bedding.
	SILTSTONE (50%) / SANDSTONE (50%): 50% light, greenish, grey, very low strength rock, thinly bedded(60-200mm) interbedded very fine to fine grained sandstone.
	SANDSTONE: Very fine to fine grained, light, greenish, grey, very low strength



VWP Description

125mm PVC to 59.4 m

SWL during geophysical logging (open hole): 21.5 mBGL on 15th March 2013

96 mm HQ core from 59.4 m to 306.4

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **VWP2 (MC5024)** page:2 of 5

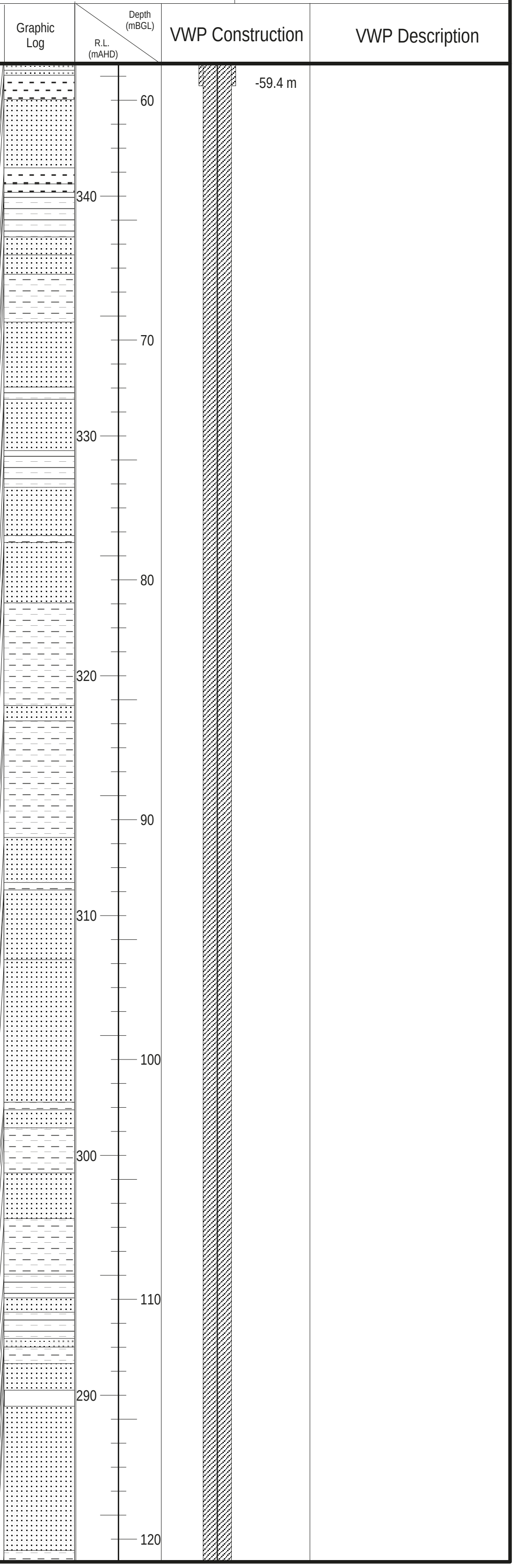
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **21/03/2013**
LOGGED BY: **W.Han**

DRILLING COMPANY: **Eastern Drilling**
DRILLER: **D.Huth**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR09**

EASTING: **408639 mE**
NORTHING: **7594209 mN**
DATUM: **GDA94Z55**
RL: **404 mAHD**
TD: **306.45 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	rock, thickly
	MUDSTONE: Mottled, greenish, grey, very low strength rock, massive/absent bedding.
	SANDSTONE: Fine grained, light, greenish, grey, lithic, silty in part, very low strength rock, thickly laminated(6-20mm).
	MUDSTONE: Mottled, greenish, grey, very low strength rock, massive/absent bedding, sedimentary dykes. Base of weathering
	SANDSTONE (50%) / MUDSTONE (50%): Light, greenish, grey, with purplish green mudstone, carbonaceous, fragments, fresh, very low strength rock.
	SANDSTONE: Fine to medium grained, light, greenish, grey, silty in part, fining upwards.
	CLAYSTONE: Medium, greenish, grey, sandy in part, near top of unit sandy, bands throughout, fresh, very low
	SANDSTONE: Fine grained, medium, greenish, grey, pebbles near middle of unit, near middle of unit, lithic, near base of unit, fresh, very low strength rock, medium bedded(200-600mm), fining upwards.
	CLAYSTONE: Medium, greenish, grey, very low strength rock, massive/absent bedding.
	CLAYSTONE: Mottled, purplish, green, low strength rock.
	MUDSTONE: Dark, greenish, grey, abundant sandy bands, clayey, low strength rock.
	SANDSTONE: Greenish, grey, low strength rock.
	SANDSTONE: Fine to medium grained, light to medium, greenish, grey, lithic, carbonaceous, silty, pebbles near base of unit, low strength rock, thinly bedded(60-200mm).
	SILTSTONE: Light to medium, greenish, grey, sandy in part near top of unit, low strength rock, thickly laminated(6-20mm).
	SANDSTONE: Fine to medium grained, light to medium, greenish, grey, lithic, carbonaceous, silty, pebbles throughout, low strength rock, medium bedded(200-600mm).
	MUDSTONE: Light to medium, greenish, grey, clayey, low strength rock.
	SANDSTONE (50%) / SILTSTONE (50%): Very fine to fine grained, light, greenish, grey, low strength rock, medium bedded(200-600mm).
	MUDSTONE: Greenish, grey, rare sandy bands, low strength rock, thinly bedded(60-200mm).
	SANDSTONE: Fine to medium grained, light, greenish, grey, silty in part, low strength rock, thinly bedded(60-200mm), sedimentary dykes.
	SILTSTONE: Grey, low strength rock.
	SANDSTONE: Fine to medium grained, greenish, grey, silty bands near top of unit, low strength rock, very thinly bedded(20-60mm).
	SILTSTONE: Light, greenish, grey, silty bands throughout, minor clay bands, low strength rock, very thinly bedded(20-60mm).
	SANDSTONE (50%) / SILTSTONE (50%): Light, greenish, grey sandstone, lithic, low strength rock, medium bedded(200-600mm) interbedded with light, greenish, grey siltstone, low strength rock, very thinly bedded(20-60mm).
	SILTSTONE: Light, greenish, grey, occasional clay bands, low strength rock, thickly laminated(6-20mm).
	SANDSTONE: Fine to coarse grained, light, grey, low strength rock, thickly laminated(6-20mm), 15.
	SILTSTONE: Light, greenish, grey, low strength rock.
	SANDSTONE: Very fine to fine grained, light, greenish, grey, rare pebbles, low strength rock, thinly laminated(<6mm).
	SANDSTONE: Fine to coarse grained, light, greenish, grey, silty in part, rare pebbles, low strength rock.
	SILTSTONE: Light to medium, greenish, grey, low strength rock, massive/absent bedding.
	SANDSTONE: very fine to coarse grained, medium, brownish, grey, lithic, rare pebbles, low strength rock/.
	SILTSTONE: Light to medium, creamy, green.
	SANDSTONE: Fine grained, light to medium, grey, lithic, low strength rock, massive/absent bedding.
	SILTSTONE: Greenish, grey, low strength rock, massive/absent bedding.
	MUDSTONE: Mottled, purplish, grey, clay in part, low strength rock, pooly developed bedding, calcite, on joints.
	SANDSTONE: Very fine to fine grained, light, greenish, grey, lithic, low strength rock, massive/absent bedding.



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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **VWP2 (MC5024)** page:3 of 5

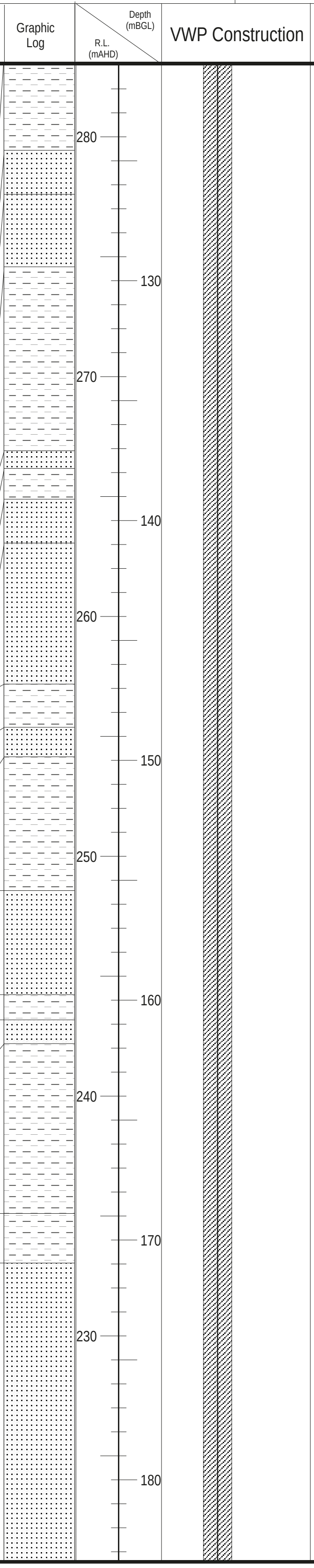
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **21/03/2013**
LOGGED BY: **W.Han**

DRILLING COMPANY: **Eastern Drilling**
DRILLER: **D.Huth**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR09**

EASTING: **408639 mE**
NORTHING: **7594209 mN**
DATUM: **GDA94Z55**
RL: **404 mAHD**
TD: **306.45 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	MUDSTONE: Medium, greenish, grey, low strength rock, massive/absent bedding.
	SANDSTONE: Light, grey, clayey near top of unit, silty bands, low strength rock.
	SILTSTONE: Light to medium, greenish, grey, low strength rock, thinly laminated(<6mm).
	SANDSTONE: Light to medium, greenish, grey, silty bands, near base of unit, low strength rock, medium bedded(200-600mm).
	NO RECOVERY:
	SANDSTONE (60%) / SILTSTONE (40%): Very fine to fine grained sandstone, light, grey, low strength rock, interbedded with greenish, grey, clayey in part, low strength rock, thickly bedded(600-2000mm).
	SILTSTONE: Greenish, grey, sandy bands, near middle of unit, low strength rock, medium bedded(200-600mm).
	SANDSTONE: Fine grained, greenish, grey, carbonaceous wisps near base of unit, low strength rock, thickly bedded(600-2000mm).
	SANDSTONE: Fine to coarse grained, grey, rare coaly, lenses, near top of unit, coarser near base of unit quartzose near base of unit, low strength rock, medium bedded(200-600mm).
	SILTSTONE: Grey, sandy bands, in part, low strength rock, thinly bedded(60-200mm).
	SANDSTONE: Light, greenish, grey, low strength rock, thickly bedded(600-2000mm).
	SILTSTONE: Light, greenish, grey, low strength rock, thickly bedded(600-2000mm).
	SANDSTONE: Fine grained, light, greenish, grey, silty bands near top of unit, low strength rock, thickly bedded(600-2000mm).
	SANDSTONE: Fine to coarse grained, light, grey, occasional silty, bands near top of unit, low strength rock, massive/absent bedding.
	SILTSTONE: Greenish, grey, clayey in part, sandy near base of unit, low strength rock, thinly bedded(60-200mm).
	SANDSTONE: Fine to coarse grained, greenish, grey, low strength rock, thickly bedded(600-2000mm).
	SILTSTONE: Grey, sandy in part, low strength rock, thickly bedded(600-2000mm).
	SANDSTONE: Fine to coarse grained, light, grey, low strength rock, thickly bedded(600-2000mm).
	SILTSTONE: Grey, low strength rock, thickly bedded(600-2000mm).
	SANDSTONE: Fine to medium grained, light, grey, silty bands near base of unit, low strength rock, thickly bedded(600-2000mm).
	SILTSTONE: Grey, occasional sandy bands, low strength rock, thinly bedded(60-200mm), minor siderite.
	SILTSTONE: Grey, occasional sandy bands, low strength rock, thinly bedded(60-200mm), minor siderite.
Betts Creek Beds (Permian)	



VWP Description

Australasian Groundwater & Environmental Consultants Pty Ltd
Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

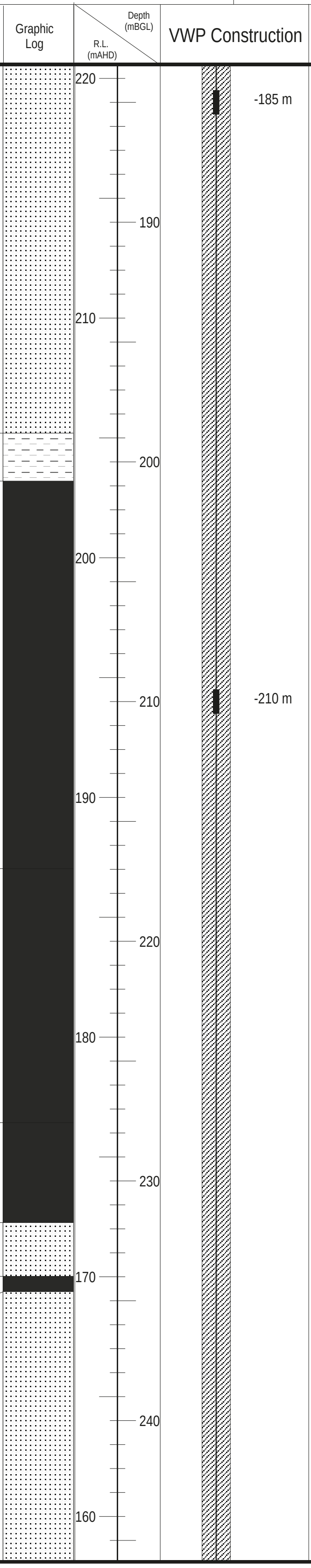
BOREHOLE ID: **VWP2 (MC5024)** page:4 of 5

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **21/03/2013**
LOGGED BY: **W.Han**

DRILLING COMPANY: **Eastern Drilling**
DRILLER: **D.Huth**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR09**

EASTING: **408639 mE**
NORTHING: **7594209 mN**
DATUM: **GDA94Z55**
RL: **404 mAHD**
TD: **306.45 mBGL**

COMMENTS: **Bore not surveyed**



Stratigraphic Interpretation	Soil or Rock Field Material Description	VWP Description
Betts Creek Beds (Permian)	SANDSTONE: Fine to medium grained, light, grey, lithic silty bands, low strength rock, medium bedded(200-600mm), minor siderite	Sensor 1. Serial no. 12-8936. Depth 185 mbGL. Lithology sandstone overburden.
	SILTSTONE: Greyish, rare sideritic bands, low strength rock, medium bedded(200-600mm).	
A Seam	COAL: Dull, discrete layers of tuff and carbonaceous siltstone throughout. A seam	Sensor 2. Serial no. 12-8932. Depth 210 mbGL. Lithology A Seam.
B Seam	COAL: Dull, discrete layers of tuff and carbonaceous siltstone throughout. B seam	
C Seam	COAL: Black. C seam	
	SANDSTONE: Fine grained, light, grey, rare silty bands, near base of unit, low strength rock.	
	COAL: Black. C4 seam	

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BOREHOLE LOG

BOREHOLE ID: **VWP2 (MC5024)** page:5 of 5

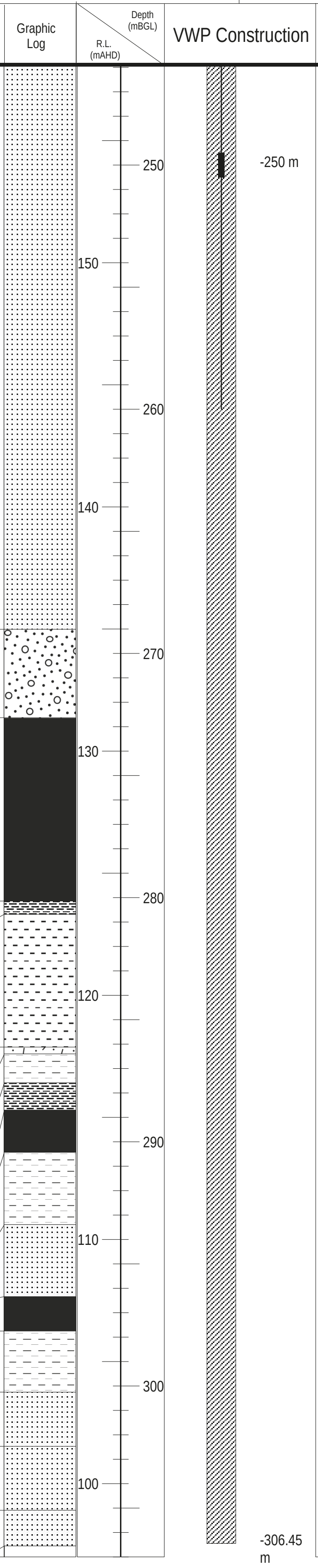
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **21/03/2013**
LOGGED BY: **W.Han**

DRILLING COMPANY: **Eastern Drilling**
DRILLER: **D.Huth**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR09**

EASTING: **408639 mE**
NORTHING: **7594209 mN**
DATUM: **GDA94Z55**
RL: **404 mAHD**
TD: **306.45 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Betts Creek Beds (Permian)	SANDSTONE: Fine to coarse grained, light, greyish, lithic, conglomeratic in part, low strength rock, massive/absent bedding.
	CONGLOMERATE: Granular to pebbly, light, greenish, grey, quartzose near base of unit, very low strength rock.
D Seam	COAL: Black, stony. D seam
	CARBONACEOUS SILTSTONE: Dark, greyish, black, very low strength rock.
	CLAYSTONE: Light, grey, tuffaceous phases, sandy in part, very low strength rock, very thickly bedded(>2m).
	TUFF: Light to medium, grey, clayey phases, very low strength rock, thinly bedded(60-200mm).
	SILTSTONE: Light to dark, grey, abundant carbonaceous wisps, low strength rock, thickly laminated(6-20mm).
E Seam	CARBONACEOUS SILTSTONE: Dark, grey, abundant carbonaceous wisps, low strength rock, thickly laminated(6-20mm).
	COAL: Black carbonacous siltstone and tuff interbedded, E seam
	SILTSTONE: Light to medium, grey, abundant sandy bands, low strength rock, thickly laminated(6-20mm).
	SANDSTONE: Coarse grained, light, grey, quartzose, very low strength rock, medium bedded(200-600mm).
	COAL: Black, F seam
	SILTSTONE: Very fine to fine grained, light, grey, abundant sandy bands, low strength rock, thickly laminated(6-20mm).
	SANDSTONE: Very fine to fine grained, grey, lithic minor carbonaceous wisps, low strength rock, thinly bedded(60-200mm).
	SANDSTONE: Coarse grained, grey, quartzose, very low strength rock, medium bedded(200-600mm).
	SANDSTONE: Fine to medium grained, light, grey, lithic, low strength rock, medium bedded(200-600mm).



VWP Description

Sensor 3. Serial no. 12-8928. Depth 250 mbGL. Lithology sandstone interburden.

BOH: 306.4 m

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BOREHOLE LOG

BOREHOLE ID: **VWP3 (MC5027)** page:1 of 6

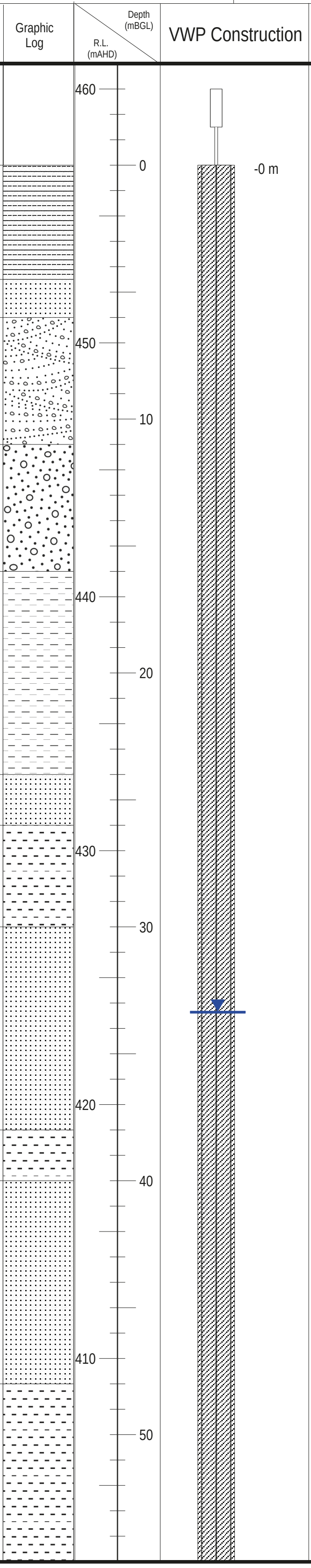
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **15/03/2013**
LOGGED BY: **B.Diaz**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **L.Hogan**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR04**

EASTING: **407582 mE**
NORTHING: **7598318 mN**
DATUM: **GDA94Z55**
RL: **457 mAHD**
TD: **348.31 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Tertiary sediments	SOIL: Red.
	SANDSTONE: Medium to coarse grained, red, extremely weathered, hard.
	IRON: Very fine grained, red, weathered.
	CONGLOMERATE: Coarse grained, reddish, brown, weathered.
Rewan Formation (Triassic)	SILTSTONE: Light, yellowish, white, clayey silty, weathered, very soft.
	SANDSTONE: Fine to medium grained, light, yellowish, white, silty in part, weathered.
	CLAYSTONE: Medium, brownish, red, sandy in part, weathered.
	SANDSTONE: Fine to medium grained, light, brownish, white, weathered.
	CLAYSTONE: Medium, brownish, red, weathered.
	SANDSTONE: Fine to medium grained, light, yellowish, white, lithic, weathered.
	CLAYSTONE: Medium, brownish, red, weathered.



VWP Description

152 mm PCD from 0 to 87 m

125mm PVC to 87 m

101.6 mm PCD from 86 to 221.35 m

96 mm HQ core from 221.35 m to 348.3 m

SWL during construction (open hole): 33.36 mBGL on the 18th March 2013

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BOREHOLE LOG

BOREHOLE ID: **VWP3 (MC5027)** page:2 of 6

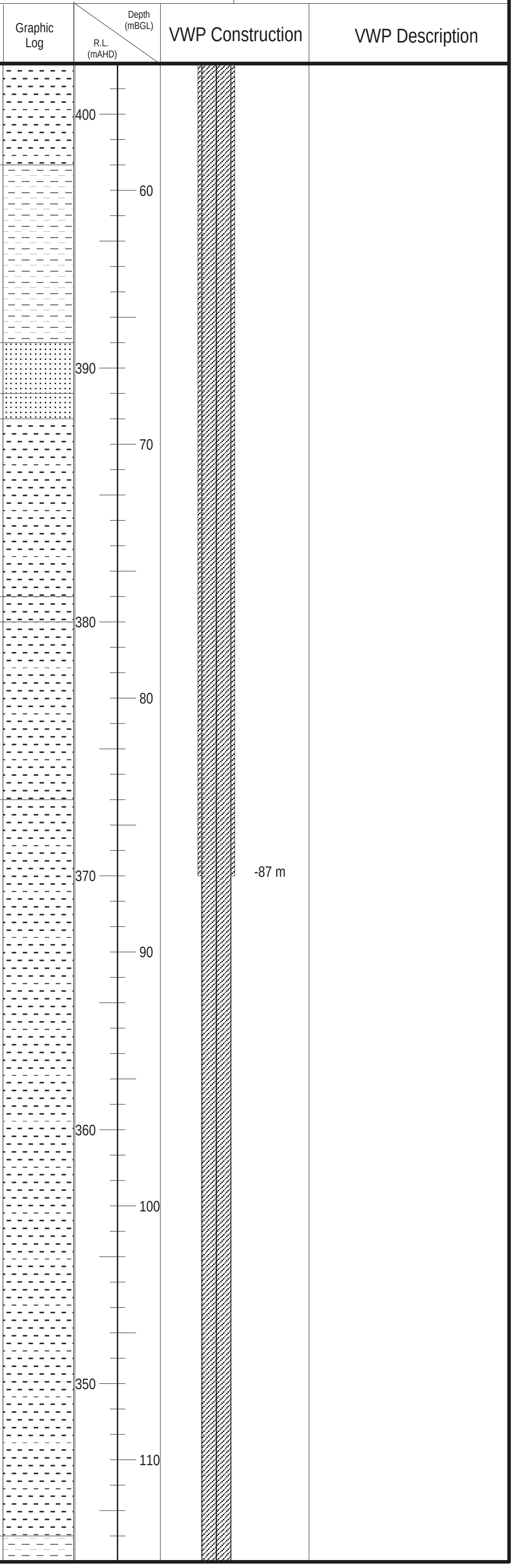
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **15/03/2013**
LOGGED BY: **B.Diaz**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **L.Hogan**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR04**

EASTING: **407582 mE**
NORTHING: **7598318 mN**
DATUM: **GDA94Z55**
RL: **457 mAHD**
TD: **348.31 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	
	SILTSTONE: Medium, brownish, red, clayey, in part.
	SANDSTONE: Fine to medium grained, light, brownish, yellow, weathered.
	SANDSTONE (50%) / CLAYSTONE (50%): Medium, brownish, red, weathered.
	CLAYSTONE: Light to medium, brownish, red, silty in part. Base of tertiary
	CLAYSTONE: Light to medium, brownish, red, weathered.
	CLAYSTONE: Light, whitish, yellow, silty in part.
	CLAYSTONE: Light to medium, blueish, brown, silty in part, weathered. Base of weathering.



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BOREHOLE LOG

BOREHOLE ID: **VWP3 (MC5027)** page:3 of 6

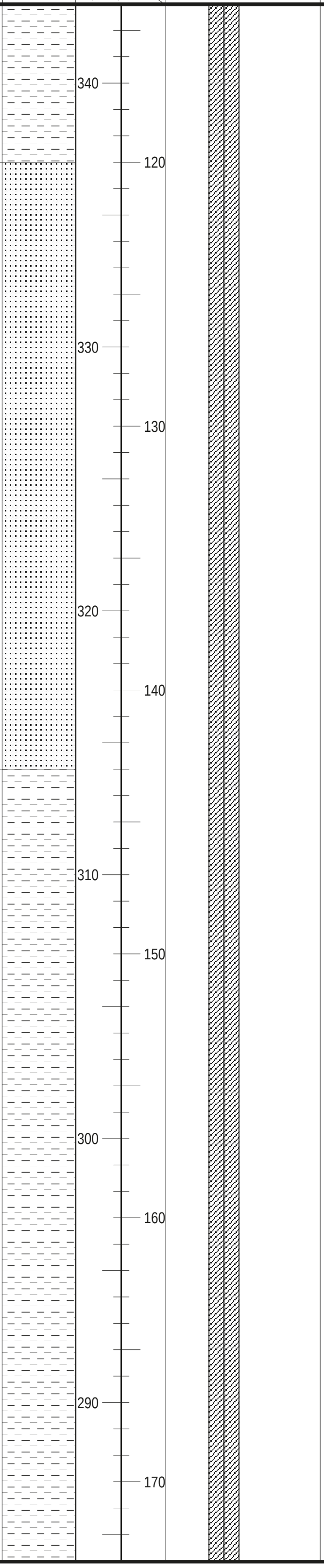
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **15/03/2013**
LOGGED BY: **B.Diaz**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **L.Hogan**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR04**

EASTING: **407582 mE**
NORTHING: **7598318 mN**
DATUM: **GDA94Z55**
RL: **457 mAHD**
TD: **348.31 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	VWP Construction	VWP Description
Rewan Formation (Triassic)	SILTSTONE: Light, blueish, grey, fresh.				
	SANDSTONE: Very fine grained, light, blueish, grey, fresh.				
	SILTSTONE: Medium, blueish, grey.				



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BOREHOLE LOG

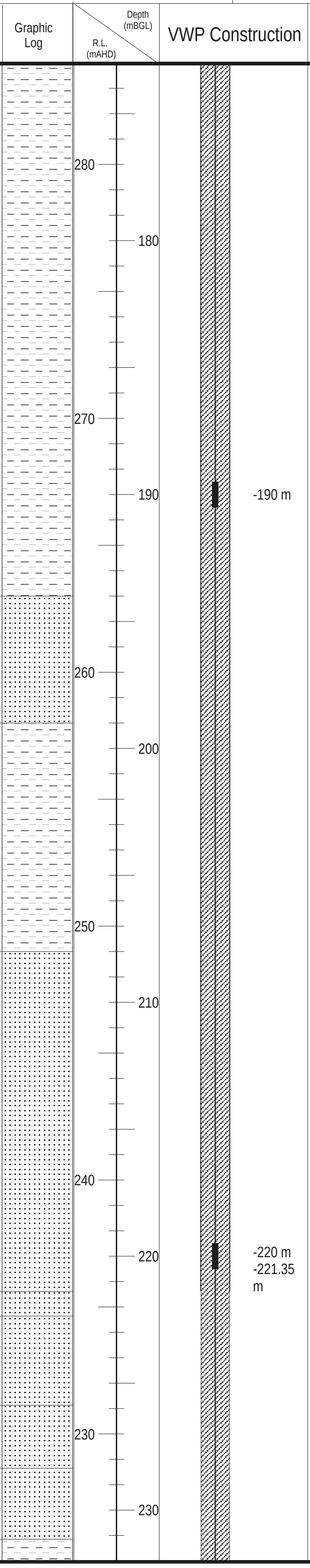
BOREHOLE ID: **VWP3 (MC5027)** page:4 of 6

PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **15/03/2013**
LOGGED BY: **B.Diaz**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **L.Hogan**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR04**

EASTING: **407582 mE**
NORTHING: **7598318 mN**
DATUM: **GDA94Z55**
RL: **457 mAHD**
TD: **348.31 mBGL**

COMMENTS: **Bore not surveyed**



Stratigraphic Interpretation	Soil or Rock Field Material Description	VWP Description
Rewan Formation (Triassic)		Sensor 1. Serial no. 12-8933. Depth 190 mbGL. Lithology Rewan Formation.
	SANDSTONE: Fine grained, light to medium, blueish, grey.	
	SILTSTONE: Medium, blueish, grey. Base of Rewan.	
Betts Creek Beds (Permian)	SANDSTONE: Fine to medium grained, light to medium, grey.	Sensor 2. Serial no. 12-8934. Depth 220 mbGL. Lithology sandstone interburden.
	SANDSTONE: Fine to medium grained, light, grey, medium strength rock.	
	SANDSTONE: Fine to medium grained, light, grey, lithic, carbonaceous, wisps, conglomeratic near base of unit, medium strength rock.	
	SANDSTONE: Fine to medium grained, light, grey, lithic, carbonaceous, wisps, conglomeratic near base of unit, medium strength r	
	SANDSTONE: Light, grey, lithic, conglomeratic, near middle of unit, carbonaceous wisps, medium strength rock.	

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BOREHOLE LOG

BOREHOLE ID: **VWP3 (MC5027)** page:5 of 6

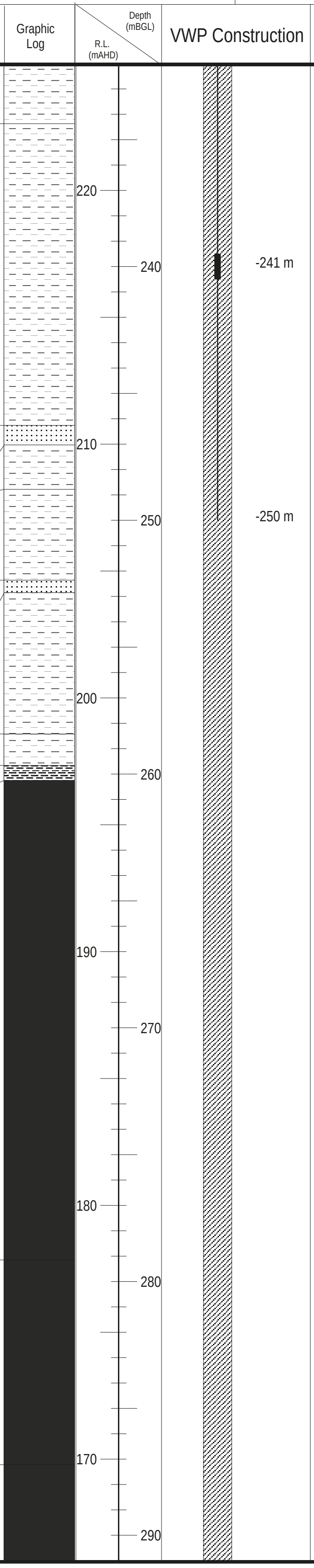
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **15/03/2013**
LOGGED BY: **B.Diaz**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **L.Hogan**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR04**

EASTING: **407582 mE**
NORTHING: **7598318 mN**
DATUM: **GDA94Z55**
RL: **457 mAHD**
TD: **348.31 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Betts Creek Beds (Permian)	SILTSTONE: Medium to dark, grey, siltstone, in part, low strength rock, thickly laminated(6-20mm).
	SILTSTONE (70%) / SANDSTONE (30%): Dark, grey siltstone, sideritic, bands, throughought interbedded with fine grained sandstone, brownish, grey, low strength rock, thinly bedded(60-200mm), sedimentary dykes.
	SANDSTONE: Fine to medium grained, dark, brownish, grey, lithic, sideritic, in part, medium strength rock.
	SILTSTONE: Dark, grey, low strength rock.
	SILTSTONE (70%) / SANDSTONE (30%): 70% dark, grey siltstone interbedded with brownish, grey sandstone, lithic, low strength rock, sedimentary dykes.
	SANDSTONE: Fine to medium grained, grey, lithic, low strength rock, thickly laminated(6-20mm).
	SILTSTONE: Dark, grey, abundant, sandstone, bands, low strength rock, very thickly bedded(>2m).
	SILTSTONE: Medium to dark, grey, low strength rock. Black.
	CARBONACEOUS CLAYSTONE: Black.
A Seam	COAL: Dull, bands of carbonaceous claystone, tuff, and siderite. A seam.
B Seam	COAL: Dull, bands of carbonaceous claystone and tuff. B seam.



VWP Description

Sensor 3. Serial no. 12-8924. Depth 240 mbGL. Lithology siltstone interburden.

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BOREHOLE LOG

BOREHOLE ID: **VWP3 (MC5027)** page:6 of 6

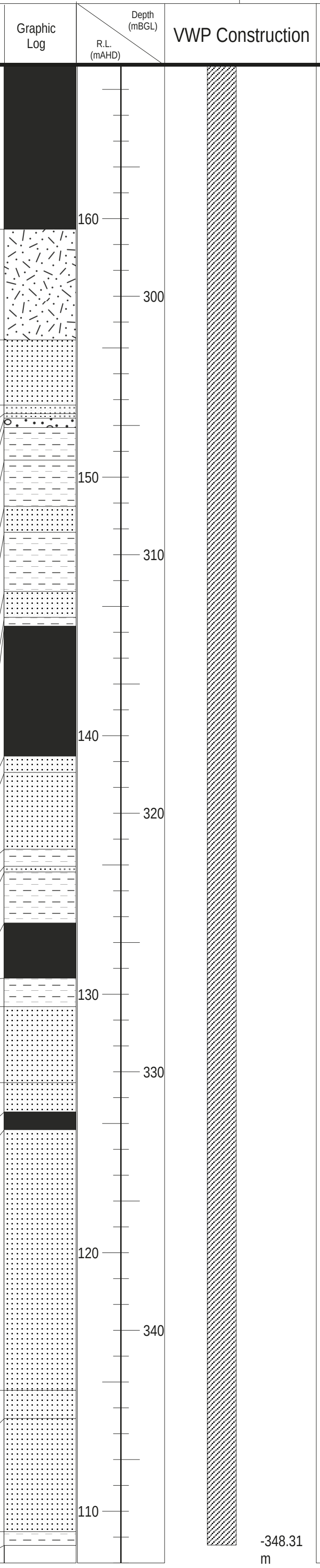
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **15/03/2013**
LOGGED BY: **B.Diaz**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **L.Hogan**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR04**

EASTING: **407582 mE**
NORTHING: **7598318 mN**
DATUM: **GDA94Z55**
RL: **457 mAHD**
TD: **348.31 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description	VWP Description
C Seam	COAL: Dull, bands of carbonaceous claystone and tuff. C seam.	
Betts Creek Beds (Permian)	TUFF: Dull, bands of carbonaceous claystone, tuff, and siderite.	
	SANDSTONE: Very fine to fine grained, grey, coaly, near top of unit, low strength rock, thickly laminated(6-20mm).	
	SANDSTONE: Medium grained, light, grey, coaly, wisps, low strength rock.	
	SANDSTONE: Fine to medium grained, light, grey, coaly, wisps, low strength rock.	
	CONGLOMERATE: Pebbly to cobbly, grey, low strength rock.	
	SILTSTONE: Light, grey, coaly, lenses, low strength rock, thinly laminated(<6mm).	
	SILTSTONE: Grey, sandstone, laminae, throughout, low strength rock, thickly laminated(6-20mm).	
	SANDSTONE: Fine to medium grained, light, grey, minor, carbonaceous, wisps, low strength rock.	
	SILTSTONE (60%) / SANDSTONE (40%): Grey siltstone, very fine to fine grained sandstone, light, grey, minor, carbonaceous, wisps, low strength rock.	
	SANDSTONE: Fine grained, light, grey, carbonaceous, wisps, siltstone, laminae, low strength rock.	
	SILTSTONE: Grey, sandstone, laminae, low strength rock, thickly laminated(6-20mm).	
D Seam	COAL: Stony, brownish, black, minor siderite. D seam	
	SANDSTONE: Very fine to fine grained, light, grey, minor, calcite, in veins.	
	SANDSTONE: Fine grained, light, grey, ww, wisps, conglomeratic, in part, medium strength rock, calcite, lenses.	
	SILTSTONE: Grey, low strength rock, thinly bedded(60-200mm).	
	SANDSTONE: Fine grained, grey, low strength rock.	
	SILTSTONE: Dark, grey, carbonaceous, in part, low strength rock, thinly laminated(<6mm).	
E Seam	COAL: Black, abundant, siderite, nodules. E seam	
	SILTSTONE: Grey, low strength rock.	
	SANDSTONE: Coarse grained, light, grey, quartzose, low strength rock.	
	SANDSTONE: Fine to medium grained, light, grey, carbonaceous, wisps, throughout, low strength rock, thickly laminated(6-20mm).	
	COAL: Dull <1% bright, tuffaceous, wisps, siderite, nodules. F seam	
Betts Creek Beds (Permian)	SANDSTONE: Fine to medium grained, light, grey, carbonaceous, throughout, quartzose, low strength rock.	
	SANDSTONE: Coarse grained, light, grey, coaly, lenses, quartzose, low strength rock.	
	SANDSTONE: Fine grained, light, whitish, grey, lithic, rare, coaly, fragments, low strength rock, massive/absent bedding.	
	SILTSTONE: Light, grey, low strength rock.	BOH: 348.3 m



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BOREHOLE LOG

BOREHOLE ID: **VWP4 (MC5030)** page:1 of 3

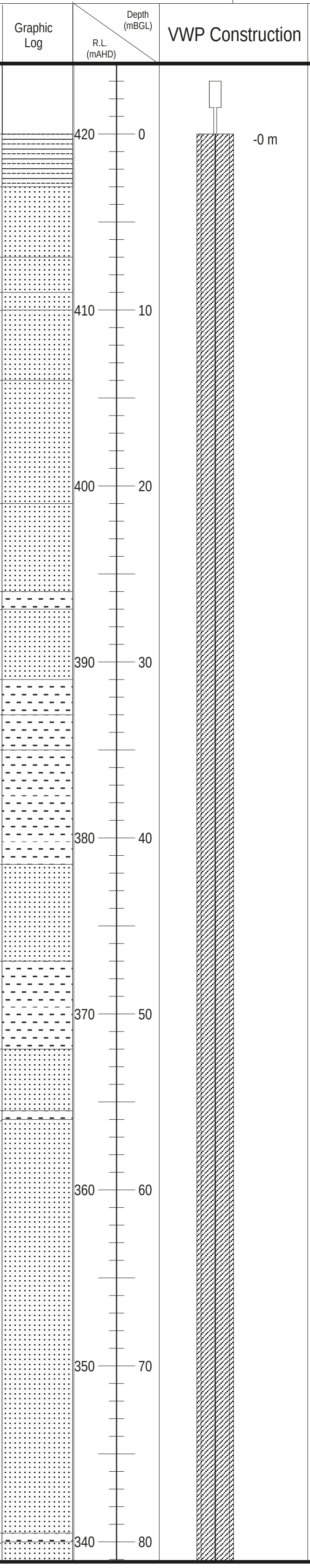
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **4/06/2013**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **S.Colles**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR09**

EASTING: **409533 mE**
NORTHING: **7602316 mN**
DATUM: **GDA94Z55**
RL: **420 mAHD**
TD: **390.47 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description	VWP Description
Tertiary sediments	SOIL: Dark, reddish, brown, sandy, extremely, weathered	
	SANDSTONE: Coarse grained, light, brownish, red, extremely, weathered	
	SANDSTONE: Fine grained, light, brownish, red, extremely, weathered	
	SANDSTONE: Very fine grained, purplish, red	
	SANDSTONE: Very fine grained, light, brownish, red, silty, throughout, extremely weathered	125mm PVC to 102 m
	SANDSTONE: Fine to medium grained, light, yellowish, red, extremely weathered	
	SANDSTONE (50 %) / SILTSTONE (50 %): Fine grained, dark, reddish, brown, extremely, weathered	96 mm HQ core from 102 m to 390.47 m
	CLAYSTONE: Dark, reddish, brown, extremely weathered	
	SANDSTONE: Fine grained, reddish, brown, silty, extremely weathered	
	CLAYSTONE: Reddish, brown, extremely weathered	
Clematis Sandstone (Triassic)	CLAYSTONE: Light, pinkish, red, extremely weathered	
	CLAYSTONE: Light, reddish, brown, extremely weathered	
	SANDSTONE: Medium to coarse grained, light, red, quartzose	
	CLAYSTONE: Reddish, brown, extremely weathered	
	SANDSTONE: Very fine grained, light, yellowish, brown, weathered	
	CLAYSTONE: Dark, brown, extremely weathered	
	SANDSTONE: Fine to medium grained, light, yellowish, brown, weathered	
	CLAYSTONE: Dark, brown, distinctly weathered	



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BOREHOLE LOG

BOREHOLE ID: **VWP4 (MC5030)** page:2 of 3

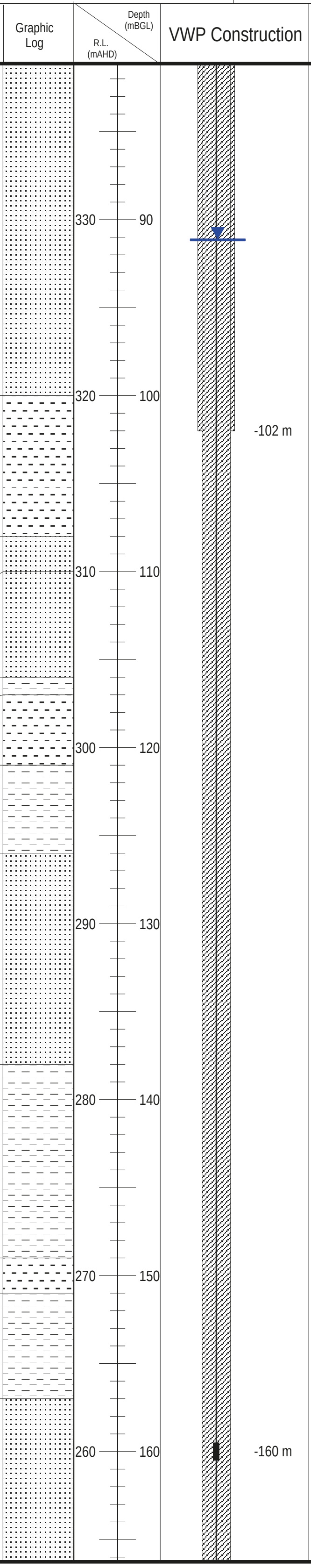
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **4/06/2013**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **S.Colles**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR09**

EASTING: **409533 mE**
NORTHING: **7602316 mN**
DATUM: **GDA94Z55**
RL: **420 mAHD**
TD: **390.47 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Clematis Sandstone (Triassic)	SANDSTONE: Fine to medium grained, light, yellowish, brown, weathered
Rewan Formation (Triassic)	CLAYSTONE: Greenish, grey, slightly weathered
	SANDSTONE: Fine grained, greenish, grey, slightly, weathered. BASE OF WEATHERING
	SANDSTONE: Fine grained, greenish, grey
	SILTSTONE: Greenish, grey
	CLAYSTONE: Greenish, grey
	SILTSTONE: Greenish, grey
	SANDSTONE: Fine grained, greenish, grey
	SILTSTONE (70 %) / CLAYSTONE (30 %): Greenish, grey
	CLAYSTONE: Greenish, grey
	SILTSTONE: Light, greenish, grey



VWP Description

SWL during construction (open hole): 90.75 mBGL on 30th May 2013

Sensor 1. Serial no. 12-8929. Depth 160 mbGL. Lithology Rewan Formation.

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BOREHOLE LOG

BOREHOLE ID: **VWP4 (MC5030)** page:3 of 3

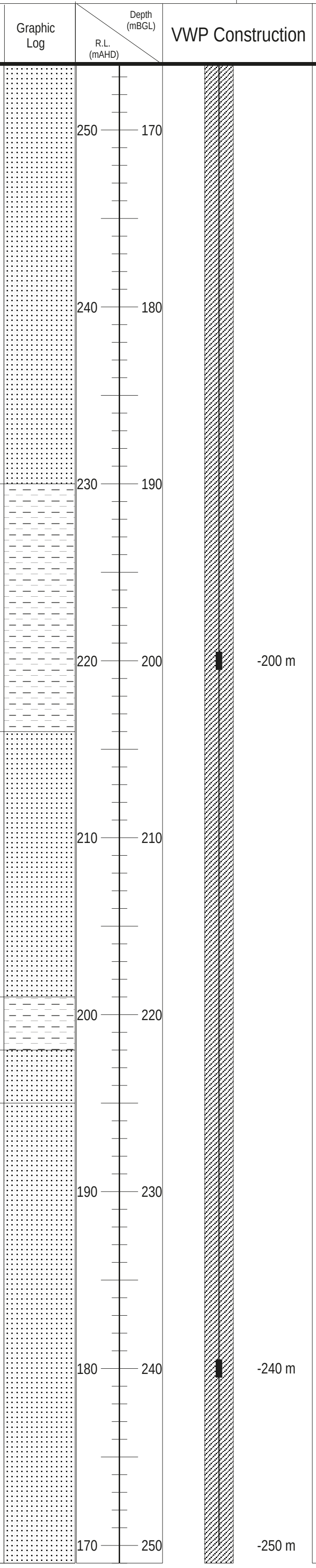
PROJECT No: **G1587A**
PROJECT NAME: **China Stone**
DATE DRILLED: **4/06/2013**
LOGGED BY: **A.Goldsmith**

DRILLING COMPANY: **Watson Drilling**
DRILLER: **S.Colles**
DRILLING METHOD: **Mud Rotary**
DRILL RIG: **WDR09**

EASTING: **409533 mE**
NORTHING: **7602316 mN**
DATUM: **GDA94Z55**
RL: **420 mAHD**
TD: **390.47 mBGL**

COMMENTS: **Bore not surveyed**

Stratigraphic Interpretation	Soil or Rock Field Material Description
Rewan Formation (Triassic)	SANDSTONE: Fine grained, greenish, grey, clayey, in part
	SILTSTONE: Greenish, grey, sandy, in part, clayey, in part
	SANDSTONE: Fine grained, light, greenish, grey
	SILTSTONE: Greenish, grey
	SANDSTONE: Fine to medium grained, light, greenish, grey.
	SANDSTONE: Fine to medium grained, light, greyish



VWP Description

Sensor 2. Serial no. 12-8930. Depth 200 mbGL. Lithology siltstone overburden.

Sensor 3. Serial no. 12-8931. Depth 240 mbGL. Lithology sandstone overburden.

Appendix A-3

Groundwater quality data

G1587 - China Stone Project

Groundwater Quality Results

Physical Parameters, Major Ions and Nutrients

Parameter	Units	LOR[a]	ANZECC GUIDELINES		NHMRC								
Sample Location			**Irrigation Water**	**Stock Water**	**Drinking Water**	**MB03**	**MB03**	**MB06**	**MB06**	**MB07**	**MB07**	**MB08**	**MB08**
Lab Number						EB1313987001	EB1408474007	EB1318364003	EB1408474004	ES1307244001	EB1408474013	ES1307244002	EB1408474012
Date Sampled						7/06/2013	2/04/2014	18/07/2013	2/04/2014	26/03/2013	3/04/2014	25/03/2013	3/04/2014
Lithology						A Seam	A Seam	A/B Seams	A/B Seams	Tertiary	Tertiary	Betts Creek	Betts Creek
Sampling Date													
Field pH	pH units		-	-	-	8.0	-	7.4	-	-	-	-	-
Field Electivcal Conductivity (EC)	µS/cm		-	-	-	1905	-	2137	-	-	-	-	-
Depth to Groundwater	m bTOC		-	-	-	59.35	-	71.71	-	-	-	-	-
Physical Parameters													
pH	pH Units	0.1	**6.0 - 8.5**	-	**6.5 - 8.5[b]**	8.1	8.0	8.0	8.4	8.1	8.1	8.2	8.1
Electrical conductivity	µS/cm	1	-	-	-	1880	2040	2840	3180	830	565	1010	1090
Sodium Absorption Ration (SAR)	-	0.01	-	-	-	9.69	-	10.4	-	7.47	-	7.24	-
Total Dissolved Solids (grav) @180°C	mg/L	1.00	-	**3000 - 13000***	**600[b]**	**1220**	**1330**	**1850**	**2070**	540	367	**656**	**708**
Total Hardness as CaCO3	mg/L	1.00	-	-	**200[b]**	192	**200**	**339**	**414**	63	116	96	114
Hydroxide Alkalinity as CaCO3	mg/L	1.00	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	1	-	-	-	<1	<1	<1	21	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	mg/L	1.00	-	-	-	72	85	290	274	65	120	109	125
Total Alkalinity as CaCO3	mg/L	1.00	-	-	-	72	85	290	295	65	120	109	125
Major Ions													
Sulfate as SO4 - Turbidimetric	mg/L	1	-	**1000 - 2000**	**500 / 250[b]**	57	65	90	101	20	10	21	21
Chloride	mg/L	1	**40**	-	**250[b]**	**541**	**530**	**743**	**728**	191	85	233	225
Fluoride	mg/L	0.1	**1.0**	**2**	**1.5**	0.3	0.3	0.6	0.6	0.6	0.6	0.4	0.4
Calcium	mg/L	1	-	**1000**	-	16	19	65	70	7	35	12	16
Magnesium	mg/L	1	-	-	-	37	37	43	58	11	7	16	18
Sodium	mg/L	1	-	-	**180[b]**	**309**	**318**	**440**	**494**	136	60	163	162
Potassium	mg/L	1	-	-	-	8	8	13	14	5	3	10	8
Total Anions	meq/L	0.01	-	-	-	17.9	18	28.6	28.5	7.1	5	9.19	9.28
Total Cations	meq/L	0.01	-	-	-	17.5	18	26.2	30.1	7.3	5.01	9.26	9.53
Ionic Balance	%	0.01	-	-	-	1.14	0.06	4.34	2.68	1.33	0.06	0.38	1.3
Nutrients													
Ammonia as N	mg/L	0.01	-	-	**0.5[b]**	0.11	0.13	**0.74**	0.35	-	0.07	-	0.05
Nitrite as N	mg/L	0.01	-	**30**	**3**	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	<0.01
Nitrate as N	mg/L	0.01	-	-	**50**	<0.01	0.02	<0.01	0.04	-	0.08	-	0.04
Nitrite + Nitrate as N	mg/L	0.01	-	**400**	-	<0.01	0.02	<0.01	0.04	-	0.08	-	0.04
Total Kjeldahl Nitrogen as N	mg/L	0.1	-	-	-	1	1.4	1.8	0.4	-	3.5	-	1.1
Total Nitrogen as N	mg/L	0.1	-	-	-	1	1.4	1.8	0.4	-	3.6	-	1.1
Total Phosphorus as P	mg/L	0.01	-	-	-	0.07	0.64	0.12	0.03	-	4.57	-	1.11
Reactive Phosphorus as P	mg/L	0.01	**0.05**	-	-	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	**0.29**

Notes:

a.	Limit of reporting
b.	Aesthetic guidelines for Drinking Water
mbTOC	metres below top of casing
0.7	Detected concentration above ANZECC (2000) Long Term Irrigation purposes
0.024	Detected concentration above ANZECC (2000) Stock purposes
0.024	Detected concentration above NHMRC (2011) Drinking Water Guidelines
*	maximum concentration at which good condition might be expected, with 13,000 mg/L for sheep, 5,000 mg/L for beef cattle, 4,000 mg/L for dairy cattle, 6,000 mg/L for horses and 3,000 mg/L for pigs and poultry.
-	No value

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Groundwater Quality Results

Physical Parameters, Major Ions and Nutrients

Parameter	Units	LOR^a	ANZECC GUIDELINES		NHMRC								
Sample Location			**Irrigation Water**	**Stock Water**	**Drinking Water**	**MB10**	**MB10**	**MB 11**	**MB11**	**MB13**	**MB13**	**MB14**	**MB14**
Lab Number						EB1318364002	EB1408474008	EB1313987002	EB1408474010	ES1307244003	EB1408474001	EB1318364005	EB1408474019
Date Sampled						18/07/2013	2/04/2014	7/06/2013	2/04/2014	25/03/2013	2/04/2014	21/07/2013	2/04/2014
Lithology						Betts Creek	Betts Creek	A/B Seams	A/B Seams	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm
Sampling Date													
Field pH	pH units		-	-	-	6.5	-	7.5	-	-	-	9.4	-
Field Electivcal Conductivity (EC)	µS/cm		-	-	-	720	-	1035	-	-	-	1729	-
Depth to Groundwater	m bTOC		-	-	-	33.69	-	35	-	-	-	133.41	-
Physical Parameters													
pH	pH Units	0.1	**6.0 - 8.5**	-	**6.5 - 8.5^b**	6.7	7.9	7.8	7.9	8.0	8.1	**9.48**	**10.1**
Electrical conductivity	µS/cm	1	-	-	-	713	768	1020	1070	4920	5290	1950	1800
Sodium Absorption Ration (SAR)	-	0.01	-	-	-	4.84	-	6.3	-	9	-	23.4	-
Total Dissolved Solids (grav) @180°C	mg/L	1.00	-	**3000 - 13000***	**600^b**	463	499	**663**	**696**	**3200**	**3440**	**1270**	**1170**
Total Hardness as CaCO3	mg/L	1.00	-	-	**200^b**	91	100	128	121	**936**	**1060**	47	117
Hydroxide Alkalinity as CaCO3	mg/L	1.00	-	-	-	<1	<1	<1	<1	<1	<1	<1	8
Carbonate Alkalinity as CaCO3	mg/L	1	-	-	-	<1	<1	<1	<1	<1	<1	81	62
Bicarbonate Alkalinity as CaCO3	mg/L	1.00	-	-	-	67	74	92	90	109	137	93	<1
Total Alkalinity as CaCO3	mg/L	1.00	-	-	-	67	74	92	90	109	137	174	69
Major Ions													
Sulfate as SO4 - Turbidimetric	mg/L	1	-	**1000 - 2000**	**500 / 250^b**	36	27	22	6	188	**288**	4	5
Chloride	mg/L	1	**40**	-	**250^b**	163	159	**288**	243	**1340**	**1350**	**551**	**553**
Fluoride	mg/L	0.1	**1.0**	**2**	**1.5**	0.2	0.2	0.3	0.3	0.1	0.2	0.4	0.3
Calcium	mg/L	1	-	**1000**	-	10	12	25	22	220	246	14	47
Magnesium	mg/L	1	-	-	-	16	17	16	16	94	109	3	<1
Sodium	mg/L	1	-	-	**180^b**	106	103	164	144	**633**	**635**	**370**	319
Potassium	mg/L	1	-	-	-	6	5	11	11	30	30	30	22
Total Anions	meq/L	0.01	-	-	-	6.69	6.53	10.4	8.78	43.9	46.8	19.1	17.1
Total Cations	meq/L	0.01	-	-	-	6.58	6.61	9.98	8.96	47	49.6	17.8	16.8
Ionic Balance	%	0.01	-	-	-	0.82	0.59	2.17	1.02	3.44	2.93	3.53	0.88
Nutrients													
Ammonia as N	mg/L	0.01	-	-	**0.5^b**	0.07	0.05	0.31	0.31	-	0.2	**1.33**	**1.82**
Nitrite as N	mg/L	0.01	-	**30**	**3**	<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	-	-	**50**	0.01	0.02	0.02	0.02	-	0.01	0.02	0.07
Nitrite + Nitrate as N	mg/L	0.01	-	**400**	-	0.01	0.02	0.02	0.02	-	0.01	0.02	0.07
Total Kjeldahl Nitrogen as N	mg/L	0.1	-	-	-	0.4	0.3	0.8	0.4	-	0.2	3.1	2.1
Total Nitrogen as N	mg/L	0.1	-	-	-	0.4	0.3	0.8	0.4	-	0.2	3.1	2.2
Total Phosphorus as P	mg/L	0.01	-	-	-	0.11	0.10	0.07	0.31	-	0.02	0.46	0.04
Reactive Phosphorus as P	mg/L	0.01	**0.05**	-	-	0.03	0.01	0.01	<0.01	-	<0.01	0.02	<0.01

Notes:

a.	Limit of reporting
b.	Aesthetic guidelines for Drinking Water
mbTOC	metres below top of casing
0.7	Detected concentration above ANZECC (2000) Long Term Irrigation purposes
0.024	Detected concentration above ANZECC (2000) Stock purposes
0.024	Detected concentration above NHMRC (2011) Drinking Water Guidelines
*	maximum concentration at which good condition might be expected, with 13,000 mg/L for sheep, 5,000 mg/L for beef cattle, 4,000 mg/L for dairy cattle, 6,000 mg/L for horses and 3,000 mg/L for pigs and poultry.
-	No value

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Groundwater Quality Results

Physical Parameters, Major Ions and Nutrients

Parameter	Units	LOR[a]	ANZECC GUIDELINES		NHMRC								
Sample Location			**Irrigation Water**	**Stock Water**	**Drinking Water**	**MB 15**	**MB15**	**MB 17**	**MB17**	**MB18**	**MB19**	**MB21**	**MB21**
Lab Number						EB1313987003	EB1408474009	EB1313987004	EB1408474003	EB1408474016	ES1307244004	EB1401396001	EB1408474006
Date Sampled						6/06/2013	1/04/2014	8/06/2013	3/04/2014	3/04/2014	25/03/2013	17/01/2014	2/04/2014
Lithology						Rewan Fm	Rewan Fm	Tertiary	Tertiary	Tertiary	Rewan Fm	Clematis SS	Clematis SS
Sampling Date													
Field pH	pH units		-	-	-	8.2	-	7.8	-	-	-	-	-
Field Electivcal Conductivity (EC)	µS/cm		-	-	-	732	-	534	-	-	-	-	-
Depth to Groundwater	m bTOC		-	-	-	86	-	63.33	-	-	-	-	-
Physical Parameters													
pH	pH Units	0.1	**6.0 - 8.5**	-	**6.5 - 8.5[b]**	8.5	**9.31**	8.0	7.9	8.5	8.5	**12.4**	**12.2**
Electrical conductivity	µS/cm	1	-	-	-	724	564	506	728	989	1000	6900	6810
Sodium Absorption Ration (SAR)	-	0.01	-	-	-	5.24	-	2.98	-	-	7.57	-	-
Total Dissolved Solids (grav) @180°C	mg/L	1.00	-	**3000 - 13000***	**600[b]**	471	367	329	473	**643**	**650**	**4480**	**4430**
Total Hardness as CaCO3	mg/L	1.00	-	-	**200[b]**	96	48	82	105	96	98	**1440**	**1340**
Hydroxide Alkalinity as CaCO3	mg/L	1.00	-	-	-	<1	<1	<1	<1	<1	<1	1980	1460
Carbonate Alkalinity as CaCO3	mg/L	1	-	-	-	12	49	<1	<1	17	14	159	49
Bicarbonate Alkalinity as CaCO3	mg/L	1.00	-	-	-	196	103	63	58	209	187	<1	<1
Total Alkalinity as CaCO3	mg/L	1.00	-	-	-	208	152	63	58	226	201	2140	1510
Major Ions													
Sulfate as SO4 - Turbidimetric	mg/L	1	-	**1000 - 2000**	**500 / 250[b]**	20	<1	12	11	47	48	7	<1
Chloride	mg/L	1	**40**	-	**250[b]**	93	80	112	161	134	154	43	34
Fluoride	mg/L	0.1	**1.0**	**2**	**1.5**	0.4	0.5	0.3	0.2	0.3	0.4	0.3	0.3
Calcium	mg/L	1	-	**1000**	-	22	16	8	9	22	21	578	539
Magnesium	mg/L	1	-	-	-	10	2	15	20	10	11	<1	<1
Sodium	mg/L	1	-	-	**180[b]**	118	91	62	85	159	172	**271**	143
Potassium	mg/L	1	-	-	-	9	11	7	8	17	22	97	49
Total Anions	meq/L	0.01	-	-	-	7.2	5.29	4.67	5.93	9.27	9.36	44.1	31.1
Total Cations	meq/L	0.01	-	-	-	7.28	5.2	4.51	6	9.27	10	43.1	34.4
Ionic Balance	%	0.01	-	-	-	0.58	0.89	1.74	0.55	0.04	3.27	1.13	4.98
Nutrients													
Ammonia as N	mg/L	0.01	-	-	**0.5[b]**	0.09	0.24	0.1	0.05	0.06	-	**13**	**8.11**
Nitrite as N	mg/L	0.01	-	**30**	**3**	<0.01	<0.01	<0.01	<0.01	<0.01	-	0.07	0.04
Nitrate as N	mg/L	0.01	-	-	**50**	0.01	0.02	0.03	0.15	0.01	-	0.02	0.1
Nitrite + Nitrate as N	mg/L	0.01	-	**400**	-	0.01	0.02	0.03	0.15	0.01	-	0.09	0.14
Total Kjeldahl Nitrogen as N	mg/L	0.1	-	-	-	0.8	0.6	0.9	0.2	2.2	-	15.7	14.4
Total Nitrogen as N	mg/L	0.1	-	-	-	0.8	0.6	0.9	0.4	2.2	-	15.8	14.5
Total Phosphorus as P	mg/L	0.01	-	-	-	0.37	0.25	0.28	0.05	2.65	-	0.20	0.54
Reactive Phosphorus as P	mg/L	0.01	**0.05**	-	-	**0.06**	0.04	<0.01	<0.01	<0.01	-	0.01	<0.01

Notes:

a.	Limit of reporting
b.	Aesthetic guidelines for Drinking Water
mbTOC	metres below top of casing
0.7	Detected concentration above ANZECC (2000) Long Term Irrigation purposes
0.024	Detected concentration above ANZECC (2000) Stock purposes
0.024	Detected concentration above NHMRC (2011) Drinking Water Guidelines
*	maximum concentration at which good condition might be expected, with 13,000 mg/L for sheep, 5,000 mg/L for beef cattle, 4,000 mg/L for dairy cattle, 6,000 mg/L for horses and 3,000 mg/L for pigs and poultry.
-	No value

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Groundwater Quality Results

Physical Parameters, Major Ions and Nutrients

Parameter	Units	LOR[a]	ANZECC GUIDELINES		NHMRC									
Sample Location			**Irrigation Water**	**Stock Water**	**Drinking Water**	**MB22**	**MB22**	**MB24**	**MB24**	**MB25**	**MB26**	**MB26**	**MB27**	**MB27**
Lab Number						EB1401396002	EB1408474014	EB1401396003	EB1408474018	EB1318364004	EB1401396004	EB1408474015	EB1401396005	EB1408474005
Date Sampled						17/01/2014	2/04/2014	19/01/2014	1/04/2014	28/07/2013	16/01/2014	1/04/2014	18/01/2014	1/04/2014
Lithology						Clematis SS	Clematis SS	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm
Sampling Date														
Field pH	pH units		-	-	-	-	-	-	-	7.3	-	-	-	-
Field Electivcal Conductivity (EC)	µS/cm		-	-	-	-	-	-	-	776	-	-	-	-
Depth to Groundwater	m bTOC		-	-	-	-	-	-	-	99.61	-	-	-	-
Physical Parameters														
pH	pH Units	0.1	**6.0 - 8.5**	-	**6.5 - 8.5[b]**	8.5	7.3	**9.66**	**9.3**	7.6	8.5	8.5	**8.57**	8.4
Electrical conductivity	µS/cm	1	-	-	-	2030	422	889	295	891	2000	1900	1310	1190
Sodium Absorption Ration (SAR)	-	0.01	-	-	-	-	-	-	-	6.84	-	-	-	-
Total Dissolved Solids (grav) @180°C	mg/L	1.00	-	**3000 - 13000***	**600[b]**	**1320**	274	578	192	579	**1300**	**1240**	**852**	**774**
Total Hardness as CaCO3	mg/L	1.00	-	-	**200[b]**	**301**	51	5	15	91	**301**	**264**	122	93
Hydroxide Alkalinity as CaCO3	mg/L	1.00	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	1	-	-	-	19	<1	50	16	<1	20	18	25	11
Bicarbonate Alkalinity as CaCO3	mg/L	1.00	-	-	-	158	29	35	29	323	162	169	180	121
Total Alkalinity as CaCO3	mg/L	1.00	-	-	-	177	29	85	45	323	182	187	206	132
Major Ions														
Sulfate as SO4 - Turbidimetric	mg/L	1	-	**1000 - 2000**	**500 / 250[b]**	6	16	19	26	2	8	7	25	30
Chloride	mg/L	1	**40**	-	**250[b]**	**540**	96	212	35	75	**540**	**477**	246	**270**
Fluoride	mg/L	0.1	**1.0**	**2**	**1.5**	0.2	0.3	0.5	0.7	0.5	0.3	0.2	0.8	0.9
Calcium	mg/L	1	-	**1000**	-	48	4	2	6	15	48	43	21	19
Magnesium	mg/L	1	-	-	-	44	10	<1	<1	13	44	38	17	11
Sodium	mg/L	1	-	-	**180[b]**	**275**	53	172	49	150	**275**	**266**	**214**	**190**
Potassium	mg/L	1	-	-	-	13	8	18	6	7	13	12	10	10
Total Anions	meq/L	0.01	-	-	-	18.9	3.62	8.07	2.43	8.61	19	17.3	11.6	10.9
Total Cations	meq/L	0.01	-	-	-	18.3	3.53	8.04	2.58	8.52	18.3	17.2	12	10.4
Ionic Balance	%	0.01	-	-	-	1.58	1.24	0.22	-	0.56	1.95	0.55	1.82	2.39
Nutrients														
Ammonia as N	mg/L	0.01	-	-	**0.5[b]**	0.05	0.06	0.07	0.17	0.32	0.07	0.03	<0.01	0.13
Nitrite as N	mg/L	0.01	-	**30**	**3**	<0.01	<0.01	0.06	0.14	<0.01	<0.01	<0.01	<0.01	0.02
Nitrate as N	mg/L	0.01	-	-	**50**	<0.01	0.6	0.31	0.17	0.02	<0.01	0.05	<0.01	0.09
Nitrite + Nitrate as N	mg/L	0.01	-	**400**	-	<0.01	0.6	0.37	0.31	0.02	<0.01	0.05	<0.01	0.11
Total Kjeldahl Nitrogen as N	mg/L	0.1	-	-	-	1.1	7	0.5	0.6	1.6	0.8	0.2	0.3	0.3
Total Nitrogen as N	mg/L	0.1	-	-	-	1.1	7.6	0.9	0.9	1.6	0.8	0.2	0.3	0.4
Total Phosphorus as P	mg/L	0.01	-	-	-	0.02	9.92	0.10	0.07	0.40	0.56	0.02	0.02	0.27
Reactive Phosphorus as P	mg/L	0.01	**0.05**	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Notes:

a.	Limit of reporting
b.	Aesthetic guidelines for Drinking Water
mbTOC	metres below top of casing
0.7	Detected concentration above ANZECC (2000) Long Term Irrigation purposes
0.024	Detected concentration above ANZECC (2000) Stock purposes
0.024	Detected concentration above NHMRC (2011) Drinking Water Guidelines
*	maximum concentration at which good condition might be expected, with 13,000 mg/L for sheep, 5,000 mg/L for beef cattle, 4,000 mg/L for dairy cattle, 6,000 mg/L for horses and 3,000 mg/L for pigs and poultry.
-	No value

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Groundwater Quality Results

Physical Parameters, Major Ions and Nutrients

Parameter	Units	LOR[a]	ANZECC GUIDELINES		NHMRC					
Sample Location			**Irrigation Water**	**Stock Water**	**Drinking Water**	**MB28**	**MB28**	**MB33**	**MB33**	**WILD BORE**
Lab Number						EB1318364006	EB1408474002	EB1318364001	EB1408474017	EB1313987005
Date Sampled						24/07/2013	1/04/2014	23/07/2013	1/04/2014	8/06/2013
Lithology						Rewan Fm	Rewan Fm	Clematis SS / Rewan Fm	Clematis SS / Rewan Fm	Clematis Sandstone?
Sampling Date										
Field pH	pH units		-	-	-	7.6	-	10.6	-	5.2
Field Electivcal Conductivity (EC)	µS/cm		-	-	-	1803	-	912	-	414
Depth to Groundwater	m bTOC		-	-	-	113.36	-	102.01	-	-
Physical Parameters										
pH	pH Units	0.1	**6.0 - 8.5**	-	**6.5 - 8.5[b]**	8.0	8.5	**9.02**	**9.36**	**5.77**
Electrical conductivity	µS/cm	1	-	-	-	1860	1650	904	332	387
Sodium Absorption Ration (SAR)	-	0.01	-	-	-	8.47	-	6.13	-	3.96
Total Dissolved Solids (grav) @180°C	mg/L	1.00	-	**3000 - 13000***	**600[b]**	**1210**	**1070**	588	216	252
Total Hardness as CaCO3	mg/L	1.00	-	-	**200[b]**	**222**	**209**	113	21	38
Hydroxide Alkalinity as CaCO3	mg/L	1.00	-	-	-	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	1	-	-	-	<1	12	79	27	<1
Bicarbonate Alkalinity as CaCO3	mg/L	1.00	-	-	-	242	104	188	44	12
Total Alkalinity as CaCO3	mg/L	1.00	-	-	-	242	117	267	71	12
Major Ions										
Sulfate as SO4 - Turbidimetric	mg/L	1	-	**1000 - 2000**	**500 / 250[b]**	12	10	19	6	11
Chloride	mg/L	1	**40**	-	**250[b]**	**485**	**430**	124	46	105
Fluoride	mg/L	0.1	**1.0**	**2**	**1.5**	0.5	0.3	0.6	0.6	0.1
Calcium	mg/L	1	-	**1000**	-	41	44	24	5	2
Magnesium	mg/L	1	-	-	-	29	24	13	2	8
Sodium	mg/L	1	-	-	**180[b]**	**290**	**220**	150	56	56
Potassium	mg/L	1	-	-	-	14	15	10	5	6
Total Anions	meq/L	0.01	-	-	-	18.8	14.7	9.23	2.84	3.43
Total Cations	meq/L	0.01	-	-	-	17.4	14.1	9.05	2.98	3.35
Ionic Balance	%	0.01	-	-	-	3.78	1.92	1.02		1.24
Nutrients										
Ammonia as N	mg/L	0.01	-	-	**0.5[b]**	0.23	0.16	0.27	0.17	0.02
Nitrite as N	mg/L	0.01	-	**30**	**3**	<0.01	0.04	<0.01	0.02	<0.01
Nitrate as N	mg/L	0.01	-	-	**50**	0.02	0.14	0.04	0.12	0.69
Nitrite + Nitrate as N	mg/L	0.01	-	**400**	-	0.02	0.18	0.04	0.14	0.69
Total Kjeldahl Nitrogen as N	mg/L	0.1	-	-	-	0.9	1.9	1.1	0.5	0.6
Total Nitrogen as N	mg/L	0.1	-	-	-	0.9	2.1	1.1	0.6	1.3
Total Phosphorus as P	mg/L	0.01	-	-	-	0.62	0.06	0.09	0.03	0.45
Reactive Phosphorus as P	mg/L	0.01	**0.05**	-	-	<0.01	<0.01	0.03	<0.01	<0.01

Notes:

a.	Limit of reporting
b.	Aesthetic guidelines for Drinking Water
mbTOC	metres below top of casing
0.7	Detected concentration above ANZECC (2000) Long Term Irrigation purposes
0.024	Detected concentration above ANZECC (2000) Stock purposes
0.024	Detected concentration above NHMRC (2011) Drinking Water Guidelines
*	maximum concentration at which good condition might be expected, with 13,000 mg/L for sheep, 5,000 mg/L for beef cattle, 4,000 mg/L for dairy cattle, 6,000 mg/L for horses and 3,000 mg/L for pigs and poultry.
-	No value

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Groundwater Quality Results

Metals

Parameter	Units	LOR[a]	ANZECC GUIDELINES		NHMRC								
Sample Location			**Irrigation Water**	**Stock Water**	**Drinking Water**	**MB03**	**MB03**	**MB06**	**MB06**	**MB07**	**MB07**	**MB08**	**MB08**
Lab Number						EB1313987001	EB1408474007	EB1318364003	EB1408474004	ES1307244001	EB1408474013	ES1307244002	EB1408474012
Date Sampled						7/06/2013	2/04/2014	18/07/2013	2/04/2014	26/03/2013	3/04/2014	25/03/2013	3/04/2014
Lithology						A Seam	A Seam	A/B Seams	A/B Seams	Tertiary	Tertiary	Betts Creek	Betts Creek
Dissolved Metals													
Aluminium	mg/L	0.01	-	-	**0.2[b]**	0.01	<0.01	0.02	0.02	<0.01	0.02	<0.01	<0.01
Antimony	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Arsenic	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Barium	mg/L	0.001	-	-	-	0.084	0.141	0.225	0.19	0.142	0.102	0.288	0.245
Beryllium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Bismuth	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	-	-	-	0.34	0.36	0.5	0.5	0.32	0.12	0.29	0.23
Cadmium	mg/L	0.0001	-	-	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Caesium	mg/L	0.001	-	-	-	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
Cerium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	-	-	-	0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	-	-	-	0.001	0.001	0.008	0.002	<0.001	0.003	<0.001	<0.001
Dysprosium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Erbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Europium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Gadolinium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Gallium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	0.017	<0.001	0.036	<0.001
Hafnium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Holmium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Indium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	-	-	-	<0.05	4.1	0.08	0.7	<0.05	<0.05	<0.05	<0.05
Lanthanum	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	mg/L	0.001	-	-	-	<0.001	0.001	0.002	0.041	<0.001	<0.001	<0.001	<0.001
Lithium	mg/L	0.001	-	-	-	0.015	0.02	0.023	0.024	0.005	0.006	0.007	0.007
Lutetium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	-	-	-	0.189	0.5	0.087	0.047	0.002	0.01	0.054	0.016
Molybdenum	mg/L	0.001	-	-	-	<0.001	<0.001	0.002	<0.001	<0.001	0.004	<0.001	<0.001
Neodymium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.001	-	-	-	0.002	0.004	0.001	<0.001	<0.001	0.005	0.002	0.002
Praseodymium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Rubidium	mg/L	0.001	-	-	-	0.026	0.029	0.021	0.022	0.01	0.008	0.026	0.027
Samarium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	mg/L	0.001	-	-	-	0.216	0.291	1.92	1.66	0.114	0.121	0.266	0.28
Tellurium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Terbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thorium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thulium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Tin	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	0.001	-	-	-	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ytterbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Yttrium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.005	-	-	-	0.02	0.019	0.526	0.008	<0.005	0.015	<0.005	<0.005
Zirconium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total Metals													
Aluminium	mg/L	0.01	**5**	**5**	-	0.3	1.45	0.69	0.01	2.98	**28**	1.44	**13**
Antimony	mg/L	0.001	-	-	**0.003**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	**0.1**	**0.5**	**0.01**	<0.001	0.003	0.001	<0.001	0.002	**0.018**	0.001	0.006
Barium	mg/L	0.001	-	-	**2**	0.095	0.174	0.248	0.189	0.366	0.522	0.353	0.571
Beryllium	mg/L	0.001	**0.1**	-	**0.06**	<0.001	0.001	<0.001	<0.001	0.002	0.004	<0.001	0.004
Bismuth	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	**0.5**	**5.0**	**4**	0.38	0.34	0.46	**0.5**	0.32	0.2	0.27	0.28
Cadmium	mg/L	0.0001	**0.01**	**0.01**	**0.002**	<0.0001	0.0003	<0.0001	<0.0001	0.0001	0.0002	<0.0001	0.0002
Caesium	mg/L	0.001	-	-	-	<0.001	0.002	0.001	0.001	<0.001	0.008	0.001	0.012
Cerium	mg/L	0.001	-	-	-	0.004	0.038	0.004	<0.001	0.01	0.432	0.011	0.169
Chromium	mg/L	0.001	**0.1**	**1.0**	**0.05**	0.002	0.009	0.005	<0.001	0.004	**0.085**	<0.001	0.019
Cobalt	mg/L	0.001	**0.05**	**1.0**	-	0.002	0.006	<0.001	<0.001	0.002	0.006	0.003	0.01
Copper	mg/L	0.001	**0.2**	**0.5**	**1[b] / 2**	0.003	0.013	0.03	0.001	0.107	0.333	0.009	0.074
Dysprosium	mg/L	0.001	-	-	-	<0.001	0.002	<0.001	<0.001	0.007	0.048	<0.001	0.01
Erbium	mg/L	0.001	-	-	-	<0.001	0.001	<0.001	<0.001	0.003	0.019	<0.001	0.004
Europium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	0.002	0.02	<0.001	0.004
Gadolinium	mg/L	0.001	-	-	-	0.001	0.003	<0.001	<0.001	0.008	0.073	0.001	0.015
Gallium	mg/L	0.001	-	-	-	<0.001	0.003	<0.001	<0.001	0.049	0.046	0.048	0.015
Hafnium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Holmium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	0.001	0.008	<0.001	0.002
Indium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	**0.2**	-	**0.3[b]**	**1.6**	**7.41**	**1.68**	**0.84**	**1.3**	**32.7**	**0.76**	**7.62**
Lanthanum	mg/L	0.001	-	-	-	0.002	0.017	0.002	<0.001	0.005	0.192	0.005	0.072
Lead	mg/L	0.001	**2.0**	**0.1**	**0.01**	0.002	0.009	0.004	<0.001	0.038	**0.2**	0.006	0.053
Lithium	mg/L	0.001	**2.5**	-	-	0.017	0.022	0.024	0.024	0.005	0.008	0.007	0.009
Lutetium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Manganese	mg/L	0.001	**0.2**	-	**0.5**	**0.2**	**0.5**	0.106	0.049	0.04	0.086	0.12	**0.3**
Molybdenum	mg/L	0.001	**0.01**	**0.15**	**0.05**	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
Neodymium	mg/L	0.001	-	-	-	0.002	0.019	0.002	<0.001	0.021	0.386	0.007	0.085
Nickel	mg/L	0.001	**0.2**	**1**	**0.02**	0.004	0.012	0.004	<0.001	0.004	**0.026**	0.004	**0.028**
Praseodymium	mg/L	0.001	-	-	-	<0.001	0.005	<0.001	<0.001	0.003	0.087	0.002	0.022
Rubidium	mg/L	0.001	-	-	-	0.029	0.037	0.024	0.023	0.015	0.047	0.03	0.068
Samarium	mg/L	0.001	-	-	-	<0.001	0.004	<0.001	<0.001	0.008	0.1	0.002	0.02
Selenium	mg/L	0.01	**0.02**	**0.02**	**0.01**	<0.01	<0.01	<0.01	<0.01	**0.01**	**0.07**	**0.01**	**0.01**
Silver	mg/L	0.001	-	-	**0.1**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	mg/L	0.001	-	-	-	0.221	0.312	1.95	1.78	0.185	0.258	0.304	0.455
Tellurium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Terbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	0.001	0.01	<0.001	0.002
Thallium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thorium	mg/L	0.001	-	-	-	<0.001	0.004	<0.001	<0.001	0.008	0.122	0.003	0.028
Thulium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Tin	mg/L	0.001	-	-	-	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium	mg/L	0.01	-	-	-	0.01	0.05	<0.01	<0.01	0.07	0.06	<0.01	0.02
Uranium	mg/L	0.001	**0.01**	**0.2**	**0.017**	<0.001	<0.001	<0.001	<0.001	0.011	**0.033**	<0.001	0.004
Vanadium	mg/L	0.01	**0.1**	-	-	<0.01	<0.01	<0.01	<0.01	0.1	0.24	<0.01	0.05
Ytterbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	0.002	0.013	<0.001	0.002
Yttrium	mg/L	0.001	-	-	-	0.001	0.011	0.002	<0.001	0.03	0.178	0.004	0.039
Zinc	mg/L	0.005	**2.0**	**20**	**3[b]**	0.05	0.029	1.14	0.007	0.032	0.216	0.02	0.109
Zirconium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	0.012	0.007	<0.005	<0.005

Notes:

a.	Limit of reporting
b.	Aesthetic guidelines for Drinking Water
mbTOC	metres below top of casing
0.7	Detected concentration above ANZECC (2000) Long Term Irrigation purposes
0.024	Detected concentration above ANZECC (2000) Stock purposes
0.024	Detected concentration above NHMRC (2011) Drinking Water Guidelines
-	No value

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Groundwater Quality Results
Metals

Parameter	Units	LOR[a]	ANZECC GUIDELINES		NHMRC										
Sample Location			**Irrigation Water**	**Stock Water**	**Drinking Water**	**MB10**	**MB10**	**MB 11**	**MB11**	**MB13**	**MB13**	**MB14**	**MB14**	**MB 15**	**MB15**
Lab Number						EB1318364002	EB1408474008	EB1313987002	EB1408474010	ES1307244003	EB1408474001	EB1318364005	EB1408474019	EB1313987003	EB1408474009
Date Sampled						18/07/2013	2/04/2014	7/06/2013	2/04/2014	25/03/2013	2/04/2014	21/07/2013	2/04/2014	6/06/2013	1/04/2014
Lithology						Betts Creek	Betts Creek	A/B Seams	A/B Seams	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm
Dissolved Metals															
Aluminium	mg/L	0.01	-	-	**0.2 [b]**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	**0.4**	**0.41**	**0.32**
Antimony	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.016	0.006	0.002	0.003
Barium	mg/L	0.001	-	-	-	0.117	0.152	0.449	0.522	0.077	0.108	0.164	0.269	0.346	0.208
Beryllium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Bismuth	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	-	-	-	0.22	0.17	0.26	0.21	0.6	0.48	0.24	0.25	0.15	0.11
Cadmium	mg/L	0.0001	-	-	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Caesium	mg/L	0.001	-	-	-	<0.001	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cerium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001
Chromium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.002	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	-	-	-	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	-	-	-	0.001	<0.001	<0.001	0.002	<0.001	0.001	0.001	<0.001	<0.001	0.002
Dysprosium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Erbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Europium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Gadolinium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Gallium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	0.009	<0.001	<0.001	<0.001	<0.001	<0.001
Hafnium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Holmium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Indium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	-	-	-	0.2	0.3	0.18	8.9	<0.05	0.7	<0.05	<0.05	0.3	0.4
Lanthanum	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	mg/L	0.001	-	-	-	<0.001	<0.001	0.003	0.002	<0.001	0.003	<0.001	0.002	<0.001	0.006
Lithium	mg/L	0.001	-	-	-	0.009	0.01	0.012	0.012	0.026	0.03	0.152	0.047	0.017	0.045
Lutetium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	-	-	-	0.145	0.182	0.3	0.3	0.6	0.7	0.003	<0.001	0.071	0.024
Molybdenum	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.02	0.01	0.002	0.005
Neodymium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.001	-	-	-	0.008	0.004	<0.001	<0.001	<0.001	<0.001	0.003	0.004	<0.001	0.005
Praseodymium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Rubidium	mg/L	0.001	-	-	-	0.016	0.016	0.034	0.034	0.075	0.088	0.06	0.031	0.015	0.022
Samarium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	mg/L	0.001	-	-	-	0.134	0.195	0.725	0.725	9.28	10.2	0.964	1.51	0.544	0.516
Tellurium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Terbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thorium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thulium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Tin	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01
Uranium	mg/L	0.001	-	-	-	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ytterbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Yttrium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.005	-	-	-	0.116	0.007	<0.005	0.099	<0.005	0.009	0.034	<0.005	0.016	0.01
Zirconium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total Metals															
Aluminium	mg/L	0.01	**5**	**5**	-	1.03	0.39	0.2	0.04	0.05	1.35	**10**	0.42	**17**	1.52
Antimony	mg/L	0.001	-	-	**0.003**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Arsenic	mg/L	0.001	**0.1**	**0.5**	**0.01**	0.001	<0.001	<0.001	<0.001	0.001	0.003	**0.018**	0.007	0.004	0.002
Barium	mg/L	0.001	-	-	**2**	0.157	0.177	0.474	0.538	0.079	0.109	0.434	0.303	0.564	0.253
Beryllium	mg/L	0.001	**0.1**	-	**0.06**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Bismuth	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	**0.5**	**5.0**	**4**	0.15	0.17	0.25	0.3	**0.5**	**0.5**	0.33	0.23	0.17	0.14
Cadmium	mg/L	0.0001	**0.01**	**0.01**	**0.002**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	0.0001
Caesium	mg/L	0.001	-	-	-	<0.001	<0.001	0.002	0.002	<0.001	0.001	0.008	<0.001	0.006	<0.001
Cerium	mg/L	0.001	-	-	-	0.007	0.004	<0.001	<0.001	<0.001	0.006	0.05	0.002	0.061	0.006
Chromium	mg/L	0.001	**0.1**	**1.0**	**0.05**	0.004	0.002	0.002	<0.001	<0.001	0.002	0.04	0.003	0.03	0.003
Cobalt	mg/L	0.001	**0.05**	**1.0**	-	0.002	0.002	<0.001	<0.001	<0.001	<0.001	0.008	<0.001	0.013	0.001
Copper	mg/L	0.001	**0.2**	**0.5**	**1[b] / 2**	0.003	0.005	<0.001	0.002	<0.001	0.003	0.051	0.004	0.025	0.004
Dysprosium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.003	<0.001
Erbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.001	<0.001
Europium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001
Gadolinium	mg/L	0.001	-	-	-	0.002	<0.001	0.001	<0.001	<0.001	<0.001	0.005	<0.001	0.006	<0.001
Gallium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	0.01	<0.001	0.008	0.001	0.008	0.001
Hafnium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Holmium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Indium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	**0.2**	-	**0.3 [b]**	**0.88**	**0.55**	**1.71**	**9.4**	**0.2**	**2.14**	**14.6**	**0.44**	**31.9**	**2.93**
Lanthanum	mg/L	0.001	-	-	-	0.002	0.002	<0.001	<0.001	<0.001	0.003	0.017	<0.001	0.02	0.002
Lead	mg/L	0.001	**2.0**	**0.1**	**0.01**	0.002	0.01	<0.001	<0.001	<0.001	0.006	0.022	0.058	0.011	0.01
Lithium	mg/L	0.001	**2.5**	-	-	0.009	0.01	0.014	0.012	0.024	0.03	0.159	0.05	0.028	0.055
Lutetium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.2**	-	**0.5**	0.164	0.17	**0.3**	**0.3**	**0.6**	**0.739**	**0.3**	0.015	**0.648**	0.12
Molybdenum	mg/L	0.001	**0.01**	**0.15**	**0.05**	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	**0.02**	**0.02**	0.001	0.006
Neodymium	mg/L	0.001	-	-	-	0.003	0.002	<0.001	<0.001	<0.001	0.003	0.026	<0.001	0.03	0.003
Nickel	mg/L	0.001	**0.2**	**1**	**0.02**	0.008	0.005	0.002	<0.001	<0.001	0.002	**0.036**	0.006	**0.03**	0.007
Praseodymium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	0.006	<0.001
Rubidium	mg/L	0.001	-	-	-	0.02	0.019	0.038	0.034	0.079	0.087	0.103	0.033	0.043	0.023
Samarium	mg/L	0.001	-	-	-	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	0.005	<0.001
Selenium	mg/L	0.01	**0.02**	**0.02**	**0.01**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	mg/L	0.001	-	-	**0.1**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	mg/L	0.001	-	-	-	0.148	0.183	0.746	0.73	9.73	11	1.72	1.64	0.71	0.564
Tellurium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Terbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thorium	mg/L	0.001	-	-	-	0.001	<0.001	<0.001	<0.001	0.001	0.002	0.006	<0.001	0.008	<0.001
Thulium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Tin	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium	mg/L	0.01	-	-	-	0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.07	<0.01	0.15	<0.01
Uranium	mg/L	0.001	**0.01**	**0.2**	**0.017**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	**0.1**	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	0.07	<0.01
Ytterbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Yttrium	mg/L	0.001	-	-	-	0.011	0.007	<0.001	<0.001	<0.001	<0.001	0.014	<0.001	0.013	0.002
Zinc	mg/L	0.005	**2.0**	**20**	**3 [b]**	0.138	0.012	0.017	<0.005	<0.005	0.012	1.26	0.053	0.06	0.018
Zirconium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Notes:

a.	Limit of reporting
b.	Aesthetic guidelines for Drinking Water
mbTOC	metres below top of casing
0.7	Detected concentration above ANZECC (2000) Long Term Irrigation purposes
0.024	Detected concentration above ANZECC (2000) Stock purposes
0.024	Detected concentration above NHMRC (2011) Drinking Water Guidelines
-	No value

G1587 - China Stone Project
Groundwater Quality Results
Metals

Parameter	Units	LOR[a]	ANZECC GUIDELINES		NHMRC										
Sample Location			**Irrigation Water**	**Stock Water**	**Drinking Water**	**MB 17**	**MB17**	**MB18**	**MB19**	**MB21**	**MB21**	**MB22**	**MB22**	**MB24**	**MB24**
Lab Number						EB1313987004	EB1408474003	EB1408474016	ES1307244004	EB1401396001	EB1408474006	EB1401396002	EB1408474014	EB1401396003	EB1408474018
Date Sampled						8/06/2013	3/04/2014	3/04/2014	25/03/2013	17/01/2014	2/04/2014	17/01/2014	2/04/2014	19/01/2014	1/04/2014
Lithology						Tertiary	Tertiary	Tertiary	Rewan Fm	Clematis SS	Clematis SS	Clematis SS	Clematis SS	Rewan Fm	Rewan Fm
Dissolved Metals															
Aluminium	mg/L	0.01	-	-	**0.2[b]**	0.01	<0.01	<0.01	<0.01	**0.57**	**0.59**	0.03	<0.01	<0.01	**1.06**
Antimony	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001
Arsenic	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.012	<0.001	<0.001	0.005
Barium	mg/L	0.001	-	-	-	0.316	0.442	0.085	0.121	1.03	1.11	0.87	0.206	0.105	0.082
Beryllium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Bismuth	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	-	-	-	0.26	0.2	0.28	0.32	<0.05	<0.05	0.28	0.12	0.24	<0.05
Cadmium	mg/L	0.0001	-	-	-	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Caesium	mg/L	0.001	-	-	-	<0.001	0.001	<0.001	<0.001	0.014	0.011	<0.001	<0.001	<0.001	<0.001
Cerium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	0.005	0.007	<0.001	<0.001	0.003	0.003
Cobalt	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	0.002	0.002	<0.001	0.001	<0.001	<0.001
Copper	mg/L	0.001	-	-	-	0.001	0.004	<0.001	<0.001	0.05	0.03	0.002	<0.001	0.001	0.012
Dysprosium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Erbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Europium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Gadolinium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Gallium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	0.015	0.005	0.004	<0.001	<0.001	<0.001	0.002
Hafnium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Holmium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Indium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	-	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05
Lanthanum	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	0.003	0.402	<0.001	<0.001	<0.001	0.003
Lithium	mg/L	0.001	-	-	-	0.004	0.004	0.01	0.01	0.376	0.313	0.018	0.005	0.02	0.006
Lutetium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	-	-	-	0.182	0.3	0.041	0.054	<0.001	<0.001	0.2	0.078	0.002	<0.001
Molybdenum	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	0.05	0.03	0.003	<0.001	0.01	0.01
Neodymium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.001	-	-	-	0.006	0.004	<0.001	<0.001	0.013	0.007	0.008	0.006	0.002	0.001
Praseodymium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Rubidium	mg/L	0.001	-	-	-	0.028	0.032	0.033	0.042	0.222	0.157	0.027	0.032	0.033	0.019
Samarium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	mg/L	0.001	-	-	-	0.111	0.146	0.655	0.704	3.44	3.85	0.86	0.052	0.308	0.31
Tellurium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Terbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thorium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thulium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Tin	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Titanium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ytterbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Yttrium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.005	-	-	-	<0.005	0.027	<0.005	<0.005	0.047	0.038	0.077	0.015	<0.005	0.006
Zirconium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total Metals															
Aluminium	mg/L	0.01	**5**	**5**	-	2.84	0.55	**16**	0.24	-	**15**	-	**40**	-	2.75
Antimony	mg/L	0.001	-	-	**0.003**	<0.001	<0.001	<0.001	<0.001	-	**0.005**	-	<0.001	-	0.001
Arsenic	mg/L	0.001	**0.1**	**0.5**	**0.01**	0.003	<0.001	0.009	0.001	-	**0.016**	-	**0.016**	-	0.004
Barium	mg/L	0.001	-	-	**2**	0.394	0.495	0.306	0.126	-	1.35	-	1.37	-	0.132
Beryllium	mg/L	0.001	**0.1**	-	**0.06**	<0.001	<0.001	0.004	<0.001	-	<0.001	-	0.003	-	<0.001
Bismuth	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	-	<0.001	-	<0.005	-	<0.001
Boron	mg/L	0.05	**0.5**	**5.0**	**4**	0.27	0.26	0.27	0.31	-	<0.05	-	<0.05	-	<0.05
Cadmium	mg/L	0.0001	**0.01**	**0.01**	**0.002**	0.0003	0.0002	0.0005	<0.0001	-	0.0007	-	0.0003	-	0.0002
Caesium	mg/L	0.001	-	-	-	0.003	0.002	0.03	<0.001	-	0.016	-	0.343	-	<0.001
Cerium	mg/L	0.001	-	-	-	0.047	0.005	0.243	0.001	-	0.04	-	3.44	-	0.009
Chromium	mg/L	0.001	**0.1**	**1.0**	**0.05**	0.006	0.002	0.031	<0.001	-	0.042	-	**0.067**	-	0.013
Cobalt	mg/L	0.001	**0.05**	**1.0**	-	0.001	0.001	0.011	<0.001	-	0.025	-	0.026	-	0.002
Copper	mg/L	0.001	**0.2**	**0.5**	**1[b] / 2**	0.015	0.008	0.1	<0.001	-	0.131	-	0.08	-	0.022
Dysprosium	mg/L	0.001	-	-	-	0.003	<0.001	0.01	<0.001	-	0.004	-	0.148	-	<0.001
Erbium	mg/L	0.001	-	-	-	<0.001	<0.001	0.003	<0.001	-	0.002	-	0.059	-	<0.001
Europium	mg/L	0.001	-	-	-	0.001	<0.001	0.004	<0.001	-	0.001	-	0.081	-	<0.001
Gadolinium	mg/L	0.001	-	-	-	0.005	<0.001	0.017	<0.001	-	0.005	-	0.273	-	<0.001
Gallium	mg/L	0.001	-	-	-	0.003	<0.001	0.02	0.017	-	0.01	-	0.288	-	0.003
Hafnium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	<0.05	-	<0.01
Holmium	mg/L	0.001	-	-	-	<0.001	<0.001	0.002	<0.001	-	<0.001	-	0.024	-	<0.001
Indium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	-	<0.001	-	<0.005	-	<0.001
Iron	mg/L	0.05	**0.2**	-	**0.3[b]**	**2.82**	**0.38**	**20.3**	**0.2**	-	**11.7**	-	**46.2**	-	**2.06**
Lanthanum	mg/L	0.001	-	-	-	0.016	0.002	0.088	<0.001	-	0.015	-	1.18	-	0.004
Lead	mg/L	0.001	**2.0**	**0.1**	**0.01**	0.008	0.01	0.018	<0.001	-	0.944	-	0.085	-	0.054
Lithium	mg/L	0.001	**2.5**	-	-	0.005	0.004	0.017	0.01	-	0.33	-	0.009	-	0.007
Lutetium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	-	<0.001	-	<0.005	-	<0.001
Manganese	mg/L	0.001	**0.2**	-	**0.5**	**0.3**	**0.4**	**0.3**	0.055	-	**0.4**	-	**1.91**	-	0.056
Molybdenum	mg/L	0.001	**0.01**	**0.15**	**0.05**	<0.001	<0.001	<0.001	<0.001	-	**0.04**	-	<0.001	-	**0.01**
Neodymium	mg/L	0.001	-	-	-	0.027	0.003	0.108	<0.001	-	0.022	-	1.84	-	0.004
Nickel	mg/L	0.001	**0.2**	**1**	**0.02**	0.012	0.005	**0.044**	0.001	-	**0.039**	-	**0.072**	-	0.013
Praseodymium	mg/L	0.001	-	-	-	0.006	<0.001	0.028	<0.001	-	0.005	-	0.431	-	<0.001
Rubidium	mg/L	0.001	-	-	-	0.037	0.036	0.23	0.044	-	0.176	-	1.73	-	0.018
Samarium	mg/L	0.001	-	-	-	0.006	<0.001	0.024	<0.001	-	0.006	-	0.422	-	<0.001
Selenium	mg/L	0.01	**0.02**	**0.02**	**0.01**	<0.01	<0.01	**0.01**	<0.01	-	<0.01	-	**0.05**	-	<0.01
Silver	mg/L	0.001	-	-	**0.1**	<0.001	<0.001	<0.001	<0.001	-	<0.001	-	<0.005	-	<0.001
Strontium	mg/L	0.001	-	-	-	0.126	0.155	1.12	0.708	-	4.1	-	0.53	-	0.339
Tellurium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	-	<0.005	-	<0.026	-	<0.005
Terbium	mg/L	0.001	-	-	-	<0.001	<0.001	0.002	<0.001	-	<0.001	-	0.034	-	<0.001
Thallium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	-	<0.001	-	0.002	-	<0.001
Thorium	mg/L	0.001	-	-	-	0.007	0.001	0.047	<0.001	-	0.004	-	0.652	-	0.001
Thulium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	-	<0.001	-	0.007	-	<0.001
Tin	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	-	0.003	-	<0.001	-	0.003
Titanium	mg/L	0.01	-	-	-	0.05	<0.01	0.09	<0.01	-	0.43	-	1.24	-	0.04
Uranium	mg/L	0.001	**0.01**	**0.2**	**0.017**	0.002	<0.001	0.004	<0.001	-	0.001	-	**0.051**	-	<0.001
Vanadium	mg/L	0.01	**0.1**	-	-	0.02	<0.01	0.07	<0.01	-	0.03	-	0.24	-	0.01
Ytterbium	mg/L	0.001	-	-	-	<0.001	<0.001	0.002	<0.001	-	0.002	-	0.039	-	<0.001
Yttrium	mg/L	0.001	-	-	-	0.007	0.001	0.036	<0.001	-	0.024	-	0.532	-	0.002
Zinc	mg/L	0.005	**2.0**	**20**	**3[b]**	0.1	0.026	0.2	<0.005	-	0.417	-	0.485	-	0.069
Zirconium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	-	0.01	-	<0.026	-	<0.005

Notes:

a.	Limit of reporting
b.	Aesthetic guidelines for Drinking Water
mbTOC	metres below top of casing
0.7	Detected concentration above ANZECC (2000) Long Term Irrigation purposes
0.024	Detected concentration above ANZECC (2000) Stock purposes
0.024	Detected concentration above NHMRC (2011) Drinking Water Guidelines
-	No value

G1587 - China Stone Project
Groundwater Quality Results
Metals

Parameter	**Units**	**LOR[a]**	**ANZECC GUIDELINES**		**NHMRC**										
Sample Location			**Irrigation Water**	**Stock Water**	**Drinking Water**	**MB25**	**MB26**	**MB26**	**MB27**	**MB27**	**MB28**	**MB28**	**MB33**	**MB33**	**WILD BORE**
Lab Number						EB1318364004	EB1401396004	EB1408474015	EB1401396005	EB1408474005	EB1318364006	EB1408474002	EB1318364001	EB1408474017	EB1313987005
Date Sampled						28/07/2013	16/01/2014	1/04/2014	18/01/2014	1/04/2014	24/07/2013	1/04/2014	23/07/2013	1/04/2014	8/06/2013
Lithology						Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	Rewan Fm	atis SS / Rewa	atis SS / Rewa	matis Sandstor
Dissolved Metals															
Aluminium	mg/L	0.01	-	-	**0.2 [b]**	0.03	<0.01	<0.01	<0.01	0.14	0.06	0.02	0.03	0.06	<0.01
Antimony	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	-	-	-	0.002	0.013	0.011	0.001	0.002	0.001	0.001	0.001	0.002	<0.001
Barium	mg/L	0.001	-	-	-	0.601	0.897	0.791	0.508	0.454	0.761	0.327	0.15	0.098	0.267
Beryllium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Bismuth	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	-	-	-	0.29	0.27	0.27	0.35	0.41	0.37	0.43	0.09	<0.05	0.08
Cadmium	mg/L	0.0001	-	-	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Caesium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Cerium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.001	0.001	0.002	<0.001
Cobalt	mg/L	0.001	-	-	-	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
Copper	mg/L	0.001	-	-	-	<0.001	<0.001	0.002	<0.001	0.008	<0.001	0.012	<0.001	0.007	<0.001
Dysprosium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Erbium	mg/L	0.001	-	-	-	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Europium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Gadolinium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Gallium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hafnium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Holmium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Indium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	-	-	-	1.8	<0.05	<0.05	<0.05	0.2	<0.05	<0.05	<0.05	<0.05	1.1
Lanthanum	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	mg/L	0.001	-	-	-	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001
Lithium	mg/L	0.001	-	-	-	0.008	0.015	0.011	0.033	0.022	0.013	0.022	0.015	0.011	0.004
Lutetium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	-	-	-	0.4	0.2	0.2	<0.001	0.087	0.4	0.052	0.008	<0.001	0.019
Molybdenum	mg/L	0.001	-	-	-	0.03	0.002	0.002	0.009	0.005	0.009	0.007	0.01	0.01	<0.001
Neodymium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.001	-	-	-	0.007	0.006	0.003	<0.001	0.006	0.002	0.016	0.002	0.002	0.006
Praseodymium	mg/L	0.001	-	-	-	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Rubidium	mg/L	0.001	-	-	-	0.014	0.025	0.023	0.017	0.019	0.019	0.026	0.018	0.012	0.028
Samarium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	mg/L	0.001	-	-	-	0.726	0.855	0.817	0.385	0.414	1.49	0.873	0.271	0.286	0.048
Tellurium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Terbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thorium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thulium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Tin	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	0.001	-	-	-	0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.002	<0.001	<0.001
Vanadium	mg/L	0.01	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ytterbium	mg/L	0.001	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Yttrium	mg/L	0.001	-	-	-	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.005	-	-	-	0.02	0.014	0.125	<0.005	0.034	0.128	0.06	0.008	<0.005	0.024
Zirconium	mg/L	0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total Metals															
Aluminium	mg/L	0.01	**5**	**5**	-	**16**	-	0.28	-	**9**	**37**	1.82	**35**	0.38	<0.01
Antimony	mg/L	0.001	-	-	**0.003**	<0.001	-	0.001	-	<0.001	<0.001	0.002	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	**0.1**	**0.5**	**0.01**	0.004	-	**0.016**	-	0.002	0.004	<0.001	0.005	0.002	<0.001
Barium	mg/L	0.001	-	-	**2**	0.878	-	0.846	-	0.631	1.21	0.276	1.12	0.087	0.281
Beryllium	mg/L	0.001	**0.1**	-	**0.06**	<0.001	-	<0.001	-	<0.001	0.002	<0.001	0.002	<0.001	<0.001
Bismuth	mg/L	0.001	-	-	-	<0.001	-	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	**0.5**	**5.0**	**4**	0.25	-	0.26	-	0.47	0.39	0.47	0.11	<0.05	0.09
Cadmium	mg/L	0.0001	**0.01**	**0.01**	**0.002**	<0.0001	-	0.0002	-	0.0002	0.0002	0.0002	0.0002	<0.0001	<0.0001
Caesium	mg/L	0.001	-	-	-	0.007	-	<0.001	-	0.005	0.012	0.001	0.014	<0.001	0.001
Cerium	mg/L	0.001	-	-	-	0.054	-	0.001	-	0.033	0.102	0.006	0.125	<0.001	<0.001
Chromium	mg/L	0.001	**0.1**	**1.0**	**0.05**	0.019	-	0.002	-	0.026	**0.069**	0.014	**0.097**	0.004	0.002
Cobalt	mg/L	0.001	**0.05**	**1.0**	-	0.014	-	<0.001	-	0.009	0.025	0.002	0.026	<0.001	0.003
Copper	mg/L	0.001	**0.2**	**0.5**	**1[b] / 2**	0.023	-	0.003	-	0.019	0.092	0.013	0.08	0.011	0.002
Dysprosium	mg/L	0.001	-	-	-	0.003	-	<0.001	-	0.002	0.005	<0.001	0.01	<0.001	<0.001
Erbium	mg/L	0.001	-	-	-	0.001	-	<0.001	-	0.001	0.002	<0.001	0.005	<0.001	<0.001
Europium	mg/L	0.001	-	-	-	0.001	-	<0.001	-	<0.001	0.002	<0.001	0.004	<0.001	<0.001
Gadolinium	mg/L	0.001	-	-	-	0.006	-	<0.001	-	0.003	0.01	<0.001	0.016	<0.001	0.001
Gallium	mg/L	0.001	-	-	-	0.008	-	<0.001	-	0.006	0.015	0.001	0.015	<0.001	<0.001
Hafnium	mg/L	0.01	-	-	-	<0.01	-	<0.01	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Holmium	mg/L	0.001	-	-	-	<0.001	-	<0.001	-	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Indium	mg/L	0.001	-	-	-	<0.001	-	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.05	**0.2**	-	**0.3 [b]**	**16.9**	-	**0.84**	-	**16.5**	**53.4**	**3**	**38.4**	**0.56**	**3.48**
Lanthanum	mg/L	0.001	-	-	-	0.02	-	<0.001	-	0.011	0.039	0.002	0.045	<0.001	<0.001
Lead	mg/L	0.001	**2.0**	**0.1**	**0.01**	0.016	-	0.017	-	0.012	0.042	0.041	0.03	<0.001	<0.001
Lithium	mg/L	0.001	**2.5**	-	-	0.012	-	0.011	-	0.026	0.026	0.024	0.026	0.008	0.004
Lutetium	mg/L	0.001	-	-	-	<0.001	-	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	**0.2**	-	**0.5**	**0.69**	-	**0.3**	-	**0.4**	**1.51**	0.078	**1.31**	0.012	0.022
Molybdenum	mg/L	0.001	**0.01**	**0.15**	**0.05**	**0.02**	-	0.002	-	0.005	0.007	0.009	0.005	**0.01**	<0.001
Neodymium	mg/L	0.001	-	-	-	0.033	-	<0.001	-	0.016	0.052	0.003	0.076	<0.001	<0.001
Nickel	mg/L	0.001	**0.2**	**1**	**0.02**	**0.037**	-	0.005	-	**0.029**	**0.062**	**0.025**	**0.072**	0.002	0.008
Praseodymium	mg/L	0.001	-	-	-	0.007	-	<0.001	-	0.004	0.012	<0.001	0.016	<0.001	<0.001
Rubidium	mg/L	0.001	-	-	-	0.062	-	0.025	-	0.047	0.085	0.032	0.109	0.012	0.03
Samarium	mg/L	0.001	-	-	-	0.007	-	<0.001	-	0.004	0.012	<0.001	0.02	<0.001	<0.001
Selenium	mg/L	0.01	**0.02**	**0.02**	**0.01**	<0.01	-	<0.01	-	<0.01	<0.01	<0.01	**0.01**	<0.01	<0.01
Silver	mg/L	0.001	-	-	**0.1**	<0.001	-	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Strontium	mg/L	0.001	-	-	-	0.946	-	0.855	-	0.461	1.99	0.793	1.07	0.218	0.048
Tellurium	mg/L	0.005	-	-	-	<0.005	-	<0.005	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Terbium	mg/L	0.001	-	-	-	<0.001	-	<0.001	-	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Thallium	mg/L	0.001	-	-	-	<0.001	-	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thorium	mg/L	0.001	-	-	-	0.011	-	0.001	-	0.004	0.02	0.001	0.022	<0.001	<0.001
Thulium	mg/L	0.001	-	-	-	<0.001	-	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Tin	mg/L	0.001	-	-	-	<0.001	-	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium	mg/L	0.01	-	-	-	0.05	-	<0.01	-	0.06	0.09	0.02	0.08	0.01	<0.01
Uranium	mg/L	0.001	**0.01**	**0.2**	**0.017**	0.002	-	<0.001	-	<0.001	0.003	<0.001	0.004	<0.001	<0.001
Vanadium	mg/L	0.01	**0.1**	-	-	0.03	-	<0.01	-	0.04	0.09	<0.01	0.09	<0.01	<0.01
Ytterbium	mg/L	0.001	-	-	-	<0.001	-	<0.001	-	<0.001	0.001	<0.001	0.004	<0.001	<0.001
Yttrium	mg/L	0.001	-	-	-	0.018	-	<0.001	-	0.012	0.024	0.001	0.057	<0.001	<0.001
Zinc	mg/L	0.005	**2.0**	**20**	**3 [b]**	0.322	-	0.029	-	0.065	1.8	0.432	**2.9**	0.09	0.038
Zirconium	mg/L	0.005	-	-	-	<0.005	-	<0.005	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Notes:

a.	Limit of reporting
b.	Aesthetic guidelines for Drinking Water
mbTOC	metres below top of casing
0.7	Detected concentration above ANZECC (2000) Long Term Irrigation purposes
0.024	Detected concentration above ANZECC (2000) Stock purposes
0.024	Detected concentration above NHMRC (2011) Drinking Water Guidelines
-	No value

Appendix B

Numerical modelling report

B1. Groundwater modelling

B1.1 Overview of groundwater modelling

Predictive numerical modelling was undertaken to assess the impact of the project on the groundwater regime. The objectives of the predictive modelling were to:

- assess the groundwater inflow to the open cut and longwall areas over the life of mine;
- simulate and predict the area of influence of dewatering and the level and rate of drawdown at specific locations;
- identify areas of potential risk where groundwater impact mitigation/control measures may be necessary;
- simulate mitigation/control strategies if adverse impacts are identified; and
- predict the impact of mine dewatering on the groundwater regime.

The key to the modelling exercise is the adequate conceptualisation of the groundwater regime. The conceptual model is a demonstration of how the groundwater system operates given the available data, and is an idealised representation of the natural system.

The conceptual groundwater model of the project site and surrounding area was developed based on geological and topographical maps, geological information from coal exploration bores drilled across the project site, a geological model developed by the proponent, installation of monitoring bores, results from previous hydrogeological investigations and relevant data from the DNRM groundwater database, as previously described in Section 7 of the main report.

B1.2 Model construction and development

B1.2.1 Model code

The modelling code was selected to meet the model objectives. Numerical simulation of groundwater flow for the project was undertaken using the MODFLOW-SURFACT code (referred to as SURFACT for the remainder of the report). SURFACT is a commercial derivative of the standard MODFLOW code, distributed by HGL and has some distinct advantages over MODFLOW that are critical for the simulation of groundwater flow for the project.

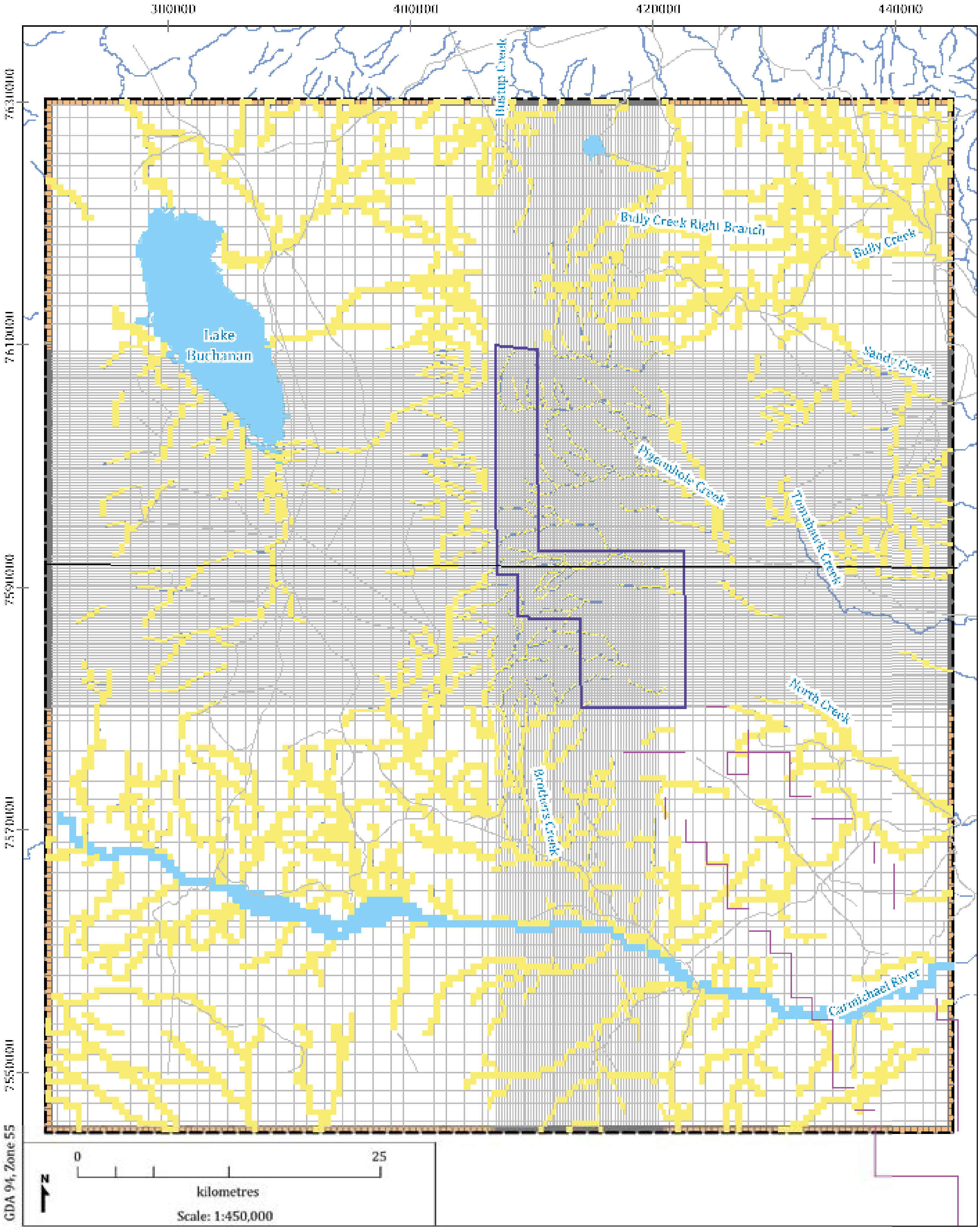
The MODFLOW code (on which SURFACT is based) is the most widely used code for groundwater modelling and is presently considered an industry standard. Use of the SURFACT modelling package is widespread, particularly in mining applications where groundwater dewatering and recovery are simulated.

SURFACT is capable of simulating unsaturated conditions. This is critical for the requirements of the project, where coal seams will be progressively dewatered during active mine operations, and re-wet following the cessation of mining. 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 input files for the SURFACT model were created using Fortran code and a SURFACT edition of the Groundwater Data Utilities (Watermark Numerical Computing, 2012). These were used to allow for the additional capabilities of SURFACT.

B1.2.2 Model geometry

The model domain is discretised into rectangular cells arranged into 18 layers comprising 507 columns and 307 rows. There are 155,649 active cells in each layer with the dimensions of the cells varying from 75 m by 75 m within the mining area up to 500 m by 500 m at the extremities of the model size. The model boundary extends 75 km from west to east, and 85 km from north to south. These dimensions provide a model domain of sufficient size to capture the full extent of any potential impacts on the groundwater system. The extent of the model was chosen to encompass the Proposed Carmichael Coal Mine Project, Carmichael River and Lake Buchanan. The active model cells cover an area of 572 km^2. Figure B 1 shows the model grid, which represents an East – West cross section through the model domain.



LEGEND:

- ⛶ Model boundary
- ☐ Model grid
- 🟧 Boundary conditions
- 🟦 Drain cell
- 🟨 River cell
- — Project site
- — Carmichael Coal Mine Project
- — Road
- — Drainage
- — Cross-section for figure B-2

Project China Stone (G1587)

Model Grid & Boundary Conditions

DATE:
24/6/2015

FIGURE No:
B-1

B1.2.3 Model layers

MBGS (2013) developed a regional geological model of the major stratigraphic units for use in the groundwater model. They used detailed data collected from the project exploration program at the site and adjacent sites, along with data from deep wells in the region outside the proposed mining area.

The numerical model represented the following key units:

- Quaternary sediments;
- Tertiary sediments;
- Weathered rock;
- Ronlow Beds;
- Triassic sediments (Moolayember Formation, Clematis Sandstone, Dunda Beds, Rewan Formation); and
- Permian Betts Creek Beds and Joe Joe Group.

Table B 1 summaries the hydrostratigraphic layers represented in the model.

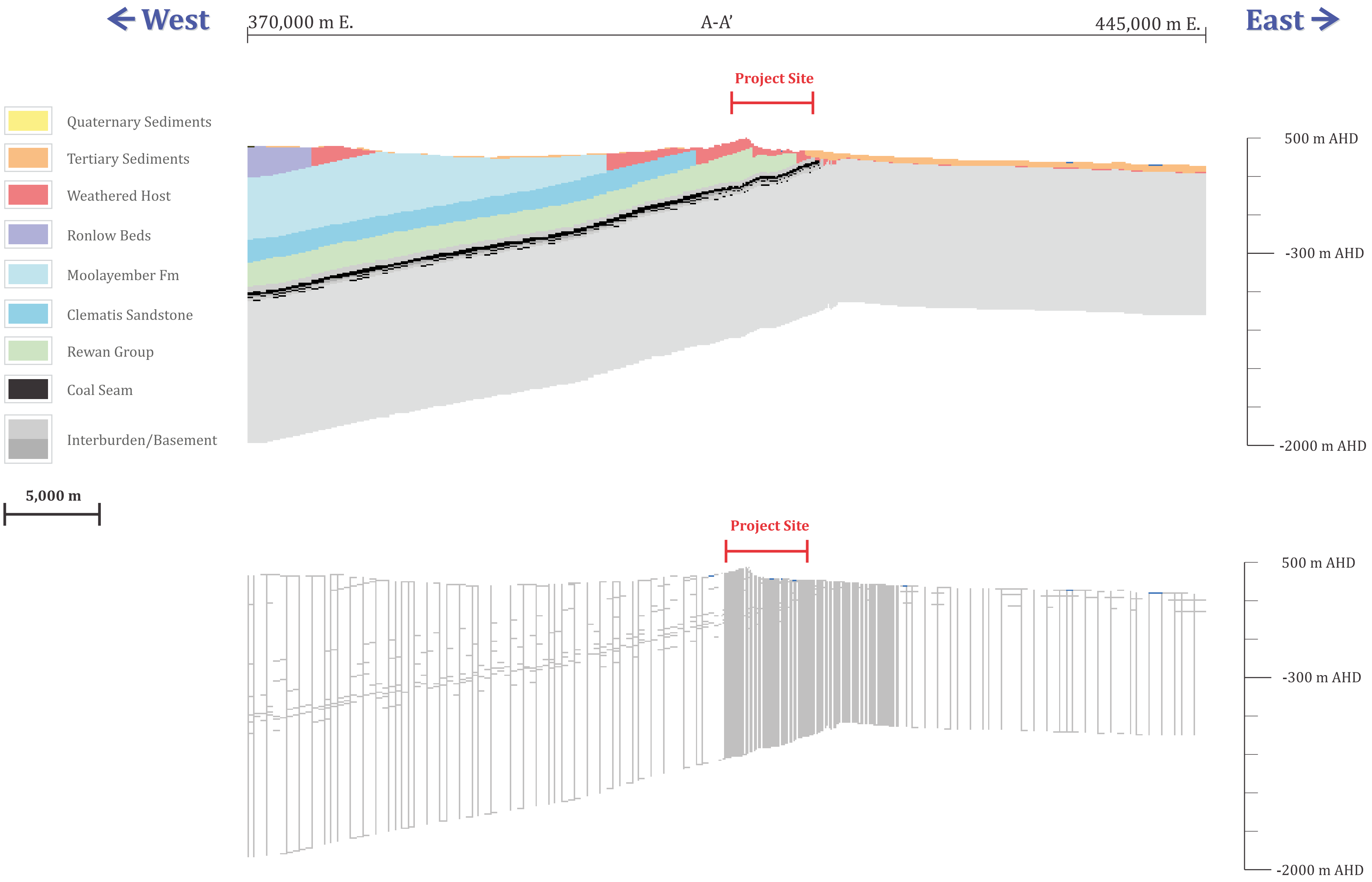
Table B 1 Model layers

Geological age	Stratigraphic unit		Model layer
Quaternary	Quaternary sediments (if present) and weathered zone		1
Tertiary	Tertiary sediments		2
Jurassic	Ronlow Beds		3
Triassic	Moolayember Formation		4
	Clematis Sandstone		5
	Dunda Beds		6
	Rewan Formation		7
			8
Permian	Betts Creek Beds	*Interburden*	9
		A Seam	10
		Interburden	11
		B Seam	12
		Interburden	13
		C Seam	14
		Interburden	15
		D Seam	16
		Interburden	17
		E Seam	
		Interburden	
		F Seam	
		Interburden	
		G Seam	
		Interburden	
	Joe Joe Group		18

The Quaternary and the Tertiary sediments are represented in the model as zones within the top two model layers. The extent of Quaternary sediments defined on the regional geology maps was used in the model. The extent of the Tertiary sediments was also based on surface geology maps and site exploration data was used to define a representative thickness. Where the Quaternary and Tertiary sediments were not present, a regolith layer was included in the model.

Two model layers accounted for the full thickness of the Rewan Formation to provide better representation of the behaviour of this key geological unit and its hydraulic conductivity. The model represented the A, B, C and D coal seams of the Betts Creek Beds as individual layers, separated by low permeability interburden.

The model represented all target coal seams with discrete layers to provide high resolution representation of the mining sequence. Figure B 2 shows a cross section through the model.



Model Grid - Cross Section - West - East

Figure B-2

Model boundaries

The model boundaries were set at a sufficient distance from the proposed mining so that the zone of depressurisation was contained well within the model.

The northern and southern boundaries were set parallel to interpreted groundwater flow directions. General head boundaries (GHBs) were conservatively adopted for all lateral model domain boundaries to allow for the transfer of groundwater to and from the model domain. This allowed for flow of water out of the model towards the west further into the GAB, if hydraulic gradients necessitated this. The hydraulic conductance for each boundary cell was assigned according to the calibrated horizontal hydraulic conductivity, multiplied by the surface area of the cell wall.

The northern and southern boundaries were set parallel to interpreted groundwater flow directions. General head boundaries (GHB) were conservatively adopted for all lateral model domain boundaries to allow for the transfer of groundwater to and from the model domain. This allowed for flow of water out of the model towards the west further into the GAB, if hydraulic gradients necessitated this. The hydraulic conductance for each boundary cell was assigned according to the calibrated horizontal hydraulic conductivity, multiplied by the surface area of the cell wall. Groundwater levels assigned to the GHB cells were based on interpolated regional groundwater levels sourced from the DNRM groundwater database.

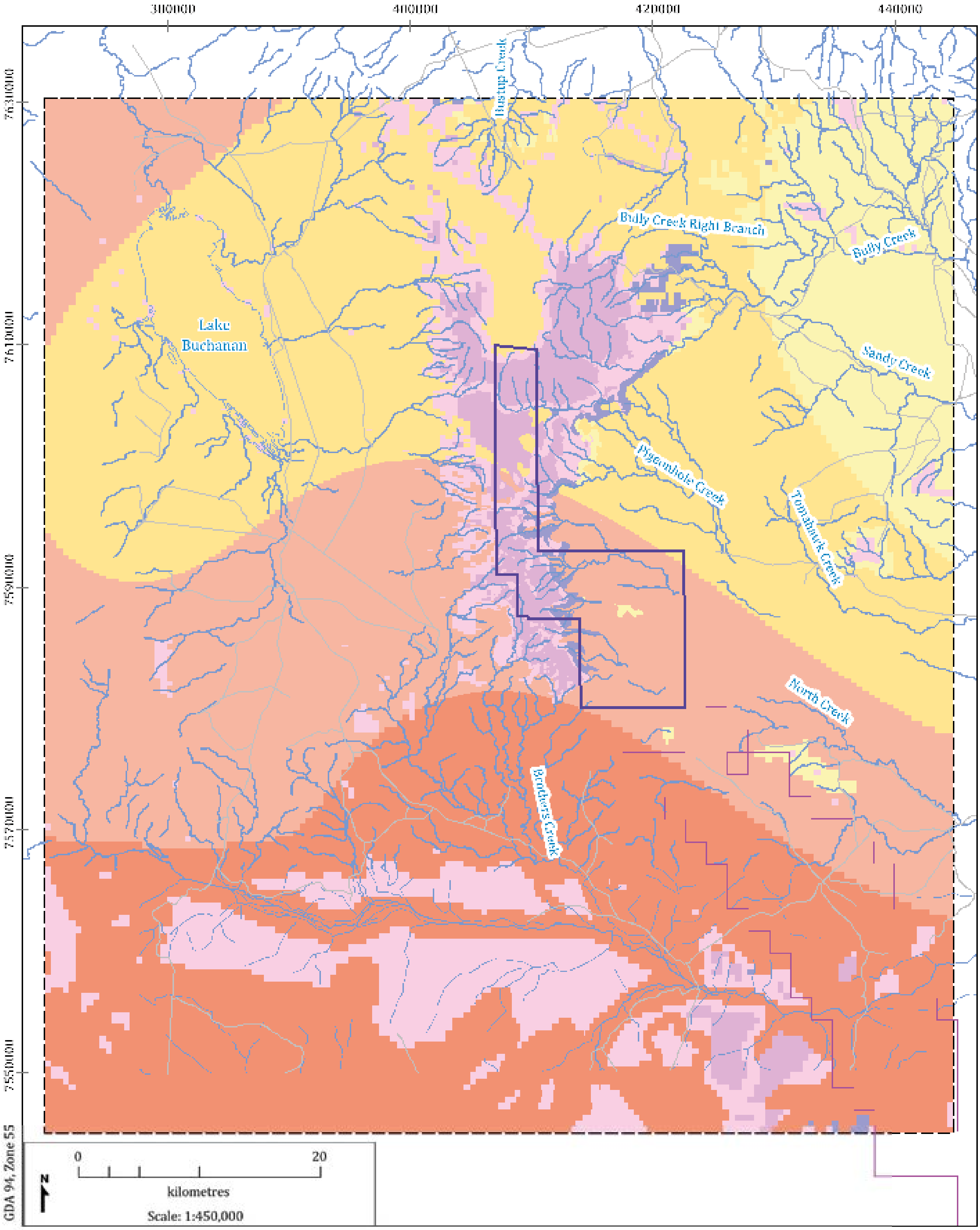
The base of the model was set as a no-flow boundary. This selection has no significant bearing on the model outcomes.

Recharge and evapotranspiration

SURFACT simulates diffuse rainfall recharge using the recharge package (RCH), and evapotranspiration from shallow water tables with the EVT package.

The model applied diffuse rainfall recharge to Layer 1. The rate of recharge was estimated during the calibration process, and set as a percentage of annual average rainfall for each geological unit. Within each geological unit, the model included a separate zone representing the break of slope at the foot of Darkies Range. This zone represented the area where runoff from the slopes collects and enhances recharge to the groundwater system. Figure B 3 shows the recharge zones.

The model represented evapotranspiration in Layer 1 with an extinction depth of 2 m. The rate of evapotranspiration was taken from the Bureau of Meteorology (BOM) evapotranspiration map of Australia, which is approximately 1,600 mm/year over the model domain.



LEGEND:

- Model boundary
- Model grid
- Project site
- Carmichael Coal Mine Project
- Road
- Drainage

Modelled recharge rates (mm/yr)

■	0.01	to	0.1
■	0.001	to	0.005
■	0.0001	to	0.001
■	0.000058	to	0.0001
■	0.000057	to	0.000058
■	0.000056	to	0.000057
■	0.00001	to	0.000056

Project China Stone (G1587)

Modelled Recharge Rates

DATE:
24/6/2015

FIGURE No:
B-3

Table B-2 presents the calibrated rate of recharge for each geological unit, and the break of slope zone within each unit. The volume of diffuse recharge (ML/day) presented in the table is based on the area of outcrop for each unit in the numerical model.

Table B 2 Modelled recharge rates

Unit	Diffuse recharge (%)	Diffuse recharge (ML/day)	Break of slope recharge (ML/day)	Break of slope recharge (%)
Quaternary sediments	0.01	0.12		
Tertiary Sediments	0.01	0.62		
Jurassic Units	0.03	0.18	0.08	0.01
Clematis Sandstone	0.30	1.13	0.13	0.05
Rewan Formation	0.12	0.08	1.92	3.19
Betts Creek Beds / Joe Joe Group	0.15	0.08	0.03	0.01
Total	**0.62**	**2.21**	**2.17**	**3.26**

Table B 2 shows that the unit with the highest rate of diffuse recharge in the model was the Clematis Sandstone, with a rate of approximately 0.3% of annual rainfall (1.8 mm/year).

Evapotranspiration occurred predominantly from Lake Buchanan where the water table is considered to occur close to the ground surface.

Surface drainage

Groundwater discharge to surface drainage was modelled using the SURFACT river package (RIV). The surface drainage elevation was taken from the digital elevation model (DEM) and was adjusted to represent the creek bed elevation at each surface water feature. The river bed conductance was calculated from river width, a riverbed thickness, and a vertical hydraulic conductivity of the riverbed material. Carmichael River, and surface water features (e.g. Lake Buchanan) were set to allow water transfer to and from the aquifer system. Table B 3 summarises the parameters representing the drainage lines and creeks.

Table B 3 Modelled river bed parameters

Kz (m/day)	Width (m)	Depth (m)	Stage height (m)	Bed thickness (m)	ID	Zone
$1.0 \times 10^{+1}$	2	1	0	1	Surface Drains	1
9.6	10	10	0.1	1	Carmichael River	2
6.8×10^{-1}	10	5	0	1	Bully Creek	3
7.5×10^{-1}	5	5	0	1	Dylingo Creek	4
1.5	5	2	0	1	Sandy Creek	5
3.2	5	2	0	1	North Creek	6
8.7×10^{-1}	2	2	0	1	Tomahawk Creek	7
9.8×10^{-3}	75	3	3	1	Minor Surface Water Feature	8
3.8×10^{-3}	500	5	5	1	Lake Buchanan	9

B1.3 Model calibration

B1.3.1 Calibration targets

All available groundwater level data was used to calibrate the model, including monitoring data installed at the project site and for the adjacent Proposed Carmichael Coal Mine Project. The model calibrated to steady state groundwater levels by adjusting the hydraulic conductivity and recharge to the uppermost layers. The median groundwater level from all available measurements was adopted as the steady state water level.

A total of 127 water level data points were used for calibration. This substantial calibration dataset was selected to provide a strong calibration result.

The calibration process weighted the water level data from each bore according to the quality of the observation target. Where a bore was known to be dry groundwater levels in the layers below the base of each calibration bore were examined to ensure unsaturated conditions occurred at each dry bore.

Water levels measured in the groundwater monitoring bores at the project site remained relatively static over the EIS monitoring period. Over this time rainfall was well below average with the area experiencing drought conditions. The groundwater monitoring therefore did not record any significant changes in groundwater level from hydraulic stresses, such as diffuse rainfall, surface water runoff, and landholder pumping. Consequently, a transient calibration to a static groundwater system was not considered beneficial. However a transient verification of the flat lining water levels was undertaken to confirm the model replicated the observations. If the verification had showed significant groundwater level variation, a transient calibration would have been considered, but this was not required.

B1.3.2 Calibration results

Table B 4 summaries the bores used in the calibration process, the measured and model predicted water levels, and the difference between levels.

Table B 4 Bore calibration targets

Bore ID	Easting GDA94 (m)	Northing GDA94 (m)	Observed water level (mAHD)	Calculated water level (mAHD)
MB04	413863	7590355		
MB05	413874	7590356	294.7	289.9
MB06	413874	7590369	294.8	289.2
MB07	415547	7590584	286.6	285.7
MB08	415553	7590570	282.9	285.7
MB09	414434	7592831		
MB10	414439	7592830	308.3	288.9
MB11	414442	7592837	308.1	288.7
MB12	410626	7590113	314.7	303.2
MB13	408638	7594223	322.3	312.4
MB14	407589	7598323	313.5	313.6
MB15	409522	7602328	323.8	321.1
MB16	417115	7585134		
MB17	417118	7585137	266.3	271.8
MB18	414442	7583778		
MB19	414446	7583780	289.8	277.5

Bore ID	Easting GDA94 (m)	Northing GDA94 (m)	Observed water level (mAHD)	Calculated water level (mAHD)
MB20	420926	7589917		
MB21	407809	7592771		
MB22	409254	7588046		
MB23	410019	7595392		
MB24	408081	7596736	352.7	313.2
MB25	407410	7596980	313.7	311.8
MB26	407115	7601043	314.8	315.3
MB27	407959	7600572		
MB28	409796	7599783	319.5	318.2
MB29	407367	7608867		
MB30	409939	7609491		
MB31	406705	7613342		
MB32	420524	7590538		
MB33	407079	7604221	320.8	317.4
VWP1_1	410643	7590108	319.0	303.2
VWP1_2	410643	7590108	315.8	300.3
VWP1_3	410643	7590108	312.4	297.8
VWP2_1	408642	7594211	305.5	309.2
VWP2_2	408642	7594211	299.7	306.5
VWP2_3	408642	7594211	297.6	306.4
VWP3_1	407578	7598319	304.9	313.6
VWP3_2	407578	7598319	296.2	312.5
VWP3_3	407578	7598319	296.6	312.5
VWP4_1	409533	7602316	328.0	321.9
VWP4_2	409533	7602316	307.2	321.7
VWP4_3	409533	7602316	297.1	321.1
5965	381254	7550613	272.0	291.3
16371	370461	7574850	315.4	316.2
16895	410061	7561628	224.5	247.7
16896	406868	7558257	245.0	253.6
17980	426849	7565142	260.4	233.6
17981	423527	7576054	265.3	248.3
17982	433592	7565399	211.3	220.8
32980	376195	7595709	356.6	305.4
39801	401187	7569715	256.8	270.6
39802	393849	7571397	258.7	281.5
47637	431780	7594906	268.3	249.6
47638	430935	7597284	269.9	252.3
47639	425622	7615420	295.2	280.8
62623	442969	7545554	235.0	214.7
90256	423671	7580878		
90257	442360	7576313	204.3	209.1
90258	426775	7565785	242.6	234.1
90259	423688	7577246	254.0	249.2
90260	436157	7551360	230.0	222.2

Bore ID	Easting GDA94 (m)	Northing GDA94 (m)	Observed water level (mAHD)	Calculated water level (mAHD)
103878	426591	7614110	271.4	275.3
BIG_BORE	394499	7591314	276.6	296.2
CAMP_BORE	416315	7592174	286.0	283.6
MOON_BORE	402814	7584618	270.0	287.9
ROO_BORE	415439	7588709	292.1	285.0
SWAMP_BORE	389547	7626125	296.0	296.5
LANE_BORE	374411	7603855	303.8	295.2
TUTOR_BORE	390274	7617086	285.9	295.7
C006P1	435726	7560833	211.3	218.6
C006P3R	435734	7560826	213.2	218.5
C007P2	434726	7559865	212.5	219.8
C007P3	434728	7559862	217.0	219.9
C008P1	433710	7558830	211.8	221.8
C008P2	433708	7558827	213.5	221.9
C011P1	428843	7569953	230.9	231.5
C011P3	428846	7569955	227.2	232.5
C012P1	430888	7569874	221.4	227.6
C012P2	430887	7569877	221.5	227.6
C014P2	430731	7563976	208.8	224.9
C016P2	422017	7574974	249.0	248.9
C018P1	423982	7574850	245.1	246.6
C018P2	423988	7574849	242.5	246.2
C018P3	423978	7574853	242.4	246.2
C020P2	427846	7566932	220.8	231.7
C022P1	426813	7565962	246.9	234.4
C024P3	428909	7571761	228.8	233.7
C025P2	438010	7555845	217.5	220.0
C027P1	433643	7554818	223.0	224.4
C027P2	433648	7554819	226.4	224.4
C029P1	437691	7555082	214.9	220.4
C029P2	437688	7555081	219.9	220.4
C034P1	442386	7547816	230.9	207.7
C034P3	442389	7547814	230.9	206.1
C035P1	441404	7546824	231.9	212.1
C035P2	441402	7546828	232.9	210.1
C056C_1	424920	7569970		
C056C_2	424920	7569970	232.2	240.3
C056C_3	424920	7569970	239.5	241.7
C180112SP	437715	7558820	219.3	217.8
C180114SP	438687	7557649	223.2	218.8
C553P_1	420993	7573965	219.1	250.2
C553P_2	420993	7573965	227.2	250.2
C555P_2	432450	7557881	219.1	223.7
C555P_3	432450	7557881	229.9	223.2
C555P1	432450	7557881	243.9	223.2

Bore ID	Easting GDA94 (m)	Northing GDA94 (m)	Observed water level (mAHD)	Calculated water level (mAHD)
C556P1	436524	7549882	249.2	222.4
C558P_1	430312	7566903	207.6	227.1
C558P_2	430312	7566903	219.7	226.9
C558P_3	430312	7566903	231.0	227.1
C558P1	430312	7566903	235.0	227.4
C823SP	433605	7562875	212.2	220.5
C825SP	434868	7561960	213.8	219.2
C827SP	436101	7560334	214.6	218.5
C829SP	436463	7559356	216.7	218.6
C832SP	439570	7554788	205.5	217.0
C833SP	439559	7554779	211.0	217.2
C834SP	439577	7554764	212.6	215.9
C840SP	439546	7552839	214.2	213.9
C844SP	441392	7546840	223.3	210.1
C9553P1R	421010	7573975	253.0	250.2
C9556PR_2	436543	7549885	223.2	220.6
C9556PR_3	436543	7549885	228.2	222.3
C9838SPR	439558	7552813	231.3	214.2
C9839SPR	439567	7552797	229.8	213.8
HD02	423823	7557008	219.1	231.9
HD03B	427559	7556119	227.2	228.1

Figure B 4 presents the observed and simulated groundwater levels graphically as a scattergram.

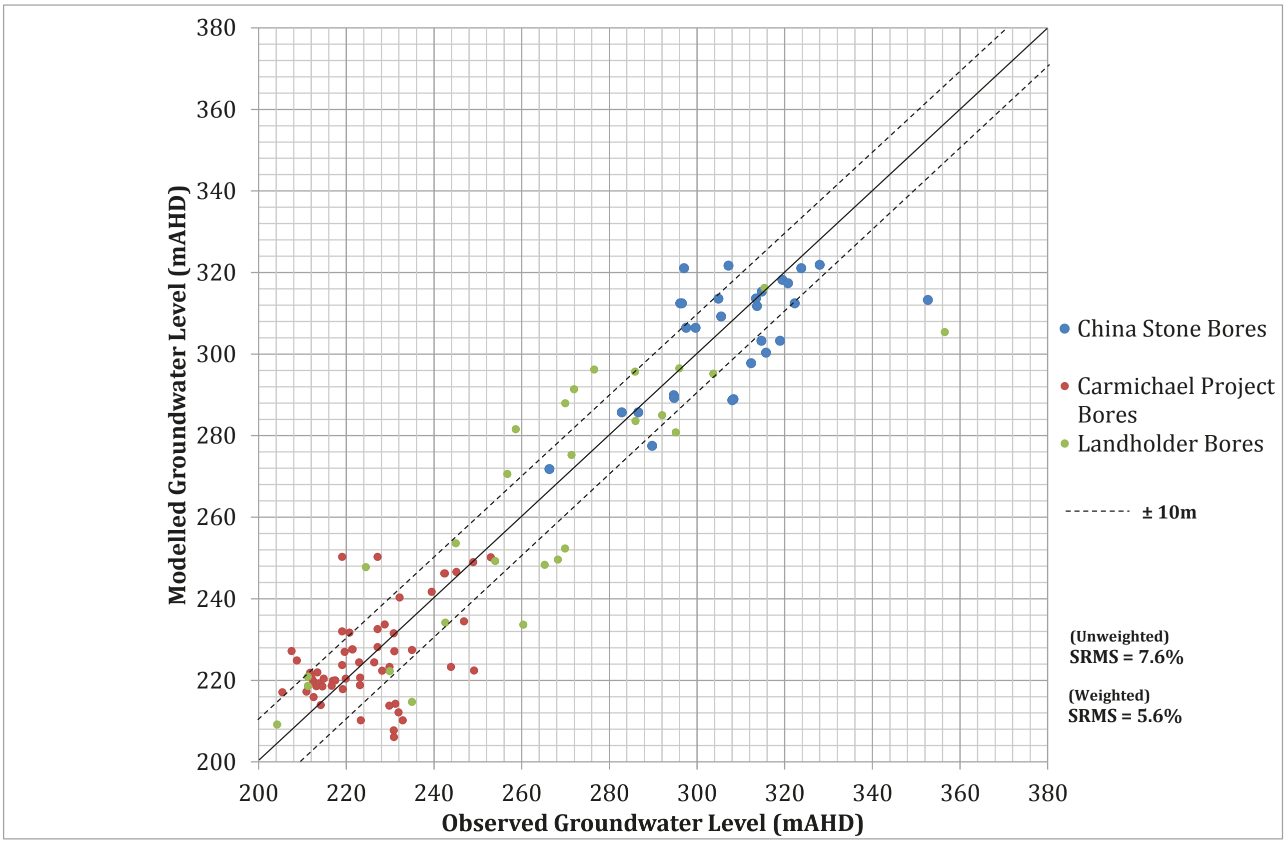


Figure B 4 Steady state calibration – modelled vs observed groundwater levels

The industry standard method to evaluate the calibration of the model is to examine the statistical parameters associated with the calibration. This is done by assessing the error between the modelled and observed (measured) water levels in terms of the root mean square (RMS). A root mean square (RMS) expressed as:

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

where:

n = number of measurements

h_o = observed water level

h_m = simulated water level

RMS is considered to be the best measure of error, if errors are normally distributed. The RMS error calculated for the calibrated model is 16.4 m.

The 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 change in the system is small, the errors are only a small part of the overall model response. The total measured head change across the model domain is 215 m; therefore, the ratio of RMS to the total head loss (SMRS) is 7.6%. Incorporating the weighted residuals into the calibration statistics reduces the RMS error to 12.1 m, with an SRMS of 5.6%. This indicates a good calibration and is within the Australian guidelines of 10% Scaled RMS (Barnett *et al*, 2012).

The model was calibrated to vibrating wire piezometers to ensure the observed vertical groundwater gradients are replicated. Figure B 5 shows the location of the pressure sensors versus groundwater pressure.

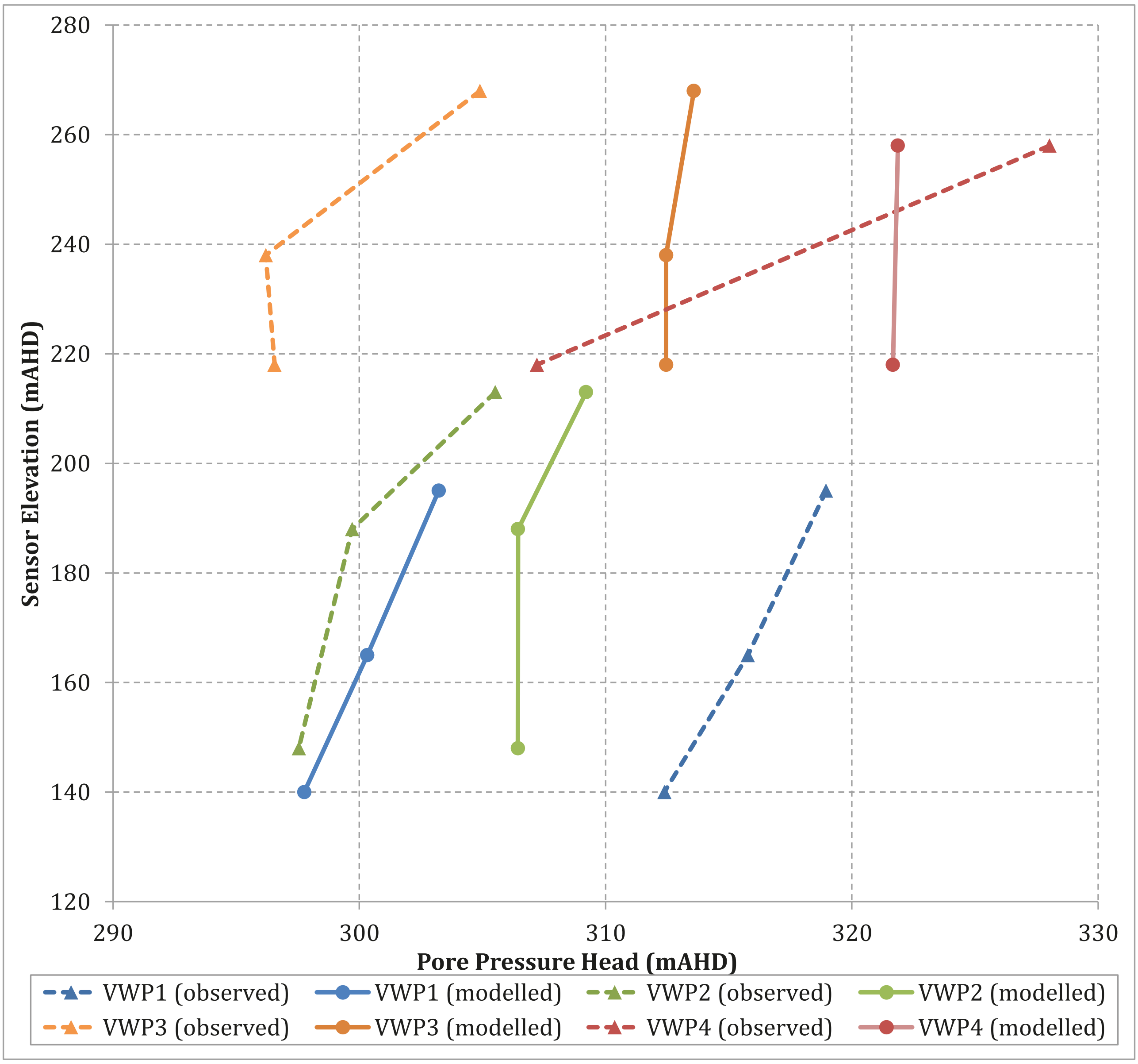


Figure B 5 Pressure head changes with depth

Whilst the model does not perfectly replicate the vertical gradients, it does simulate a downward gradient, which occurs along the Darkies Range and is typical of recharge areas.

B1.3.3 Calibration heads

Figure B 6 shows the calibrated heads:

- Layer 2 - Tertiary sediments; and
- Layer 4 - Moolayember Formation.

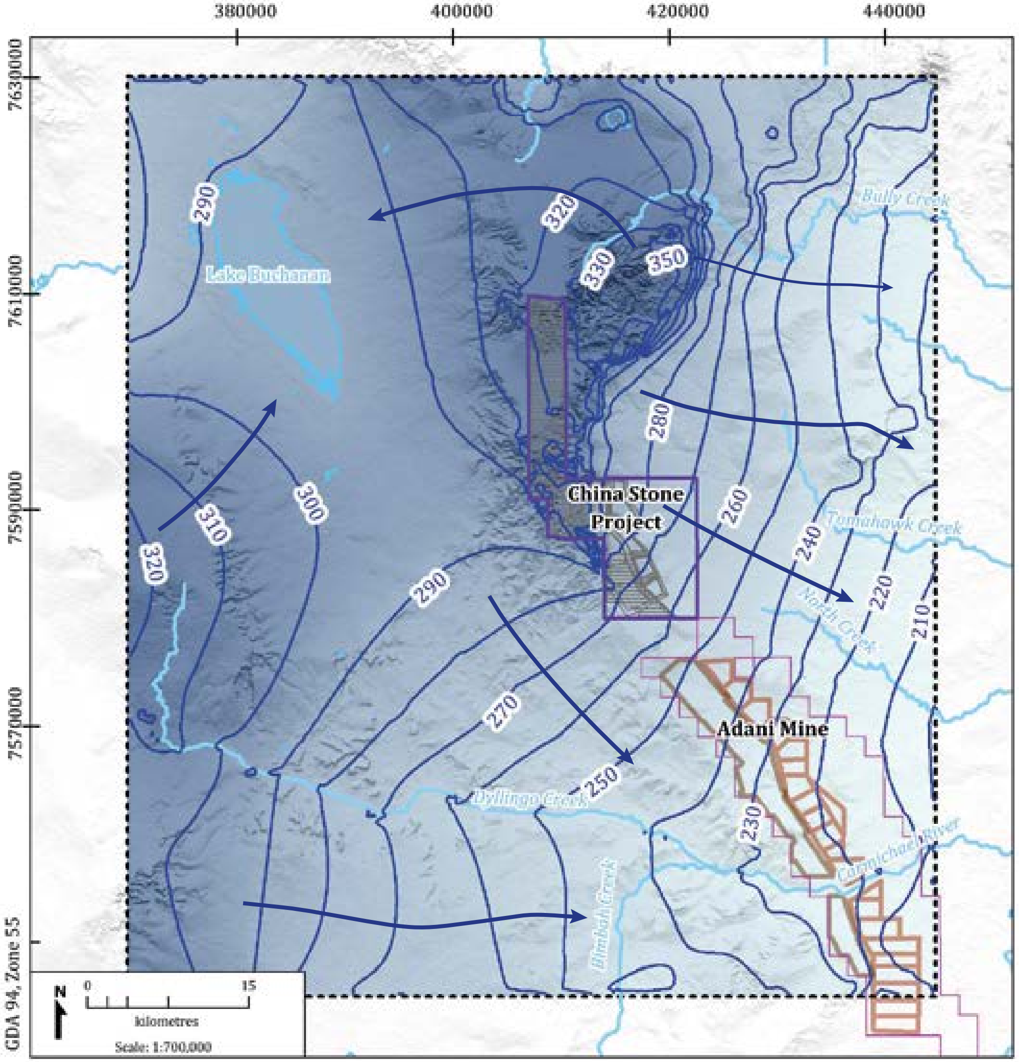
Figure B 7 shows calibrated heads for:

- Layer 5 - Clematis Sandstone; and
- Layer 8 – Rewan Formation.

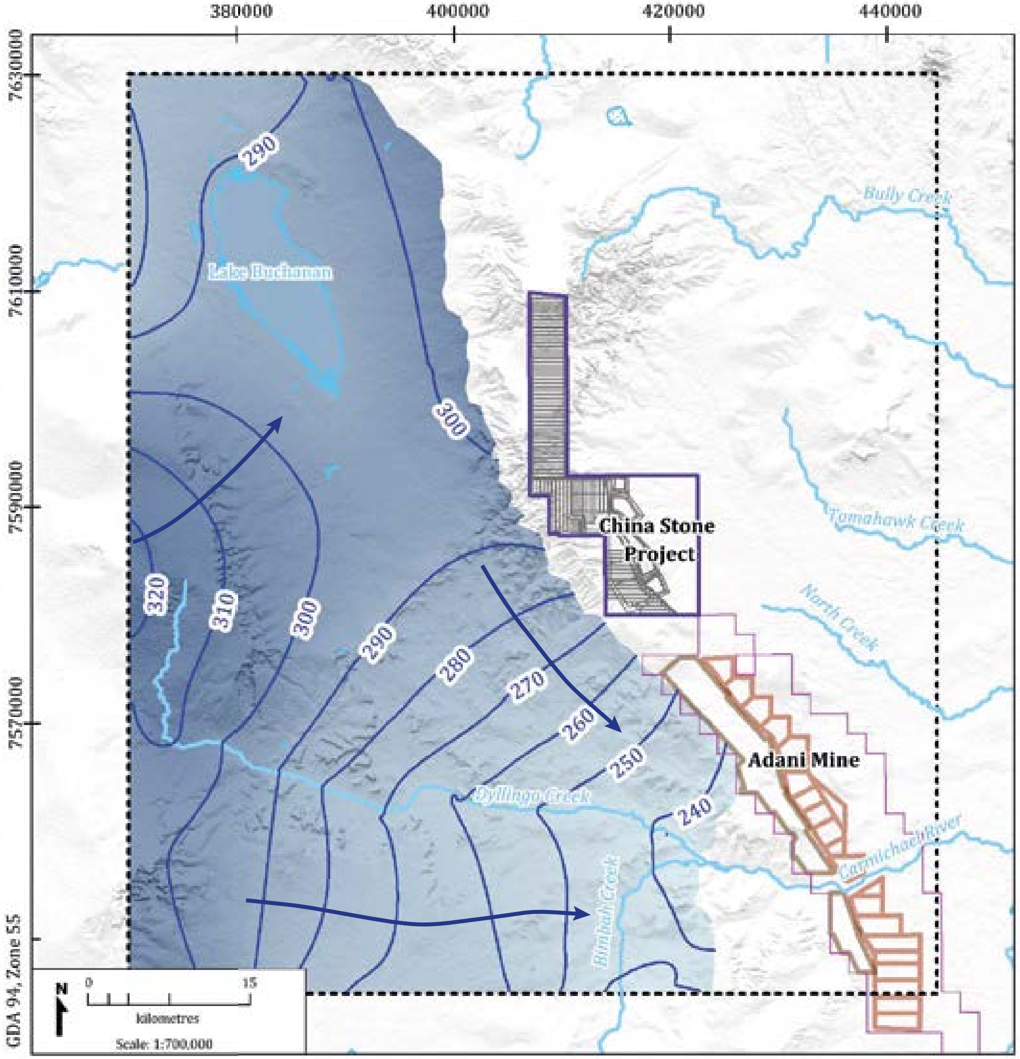
Figure B 8 shows calibrated heads for:

- Layer 10 - A coal seam; and
- Layer 10 – Joe Joe Group.

Modelled Steady State Heads - Tertiary (Layer 2)



Modelled Steady State Heads - Moolayember Formation (Layer 4)



LEGEND:

— Steady state groundwater contour (mAHD)

— Major Drainage

⬚ Model extent

▭ Project site

▭ Proposed China Stone mine

→ Groundwater flow direction

Project China Stone (G1587)
Appendix D - Modelling

Steady State Heads
Layer 2 and Layer 4

DATE:
24/6/2015

FIGURE No:
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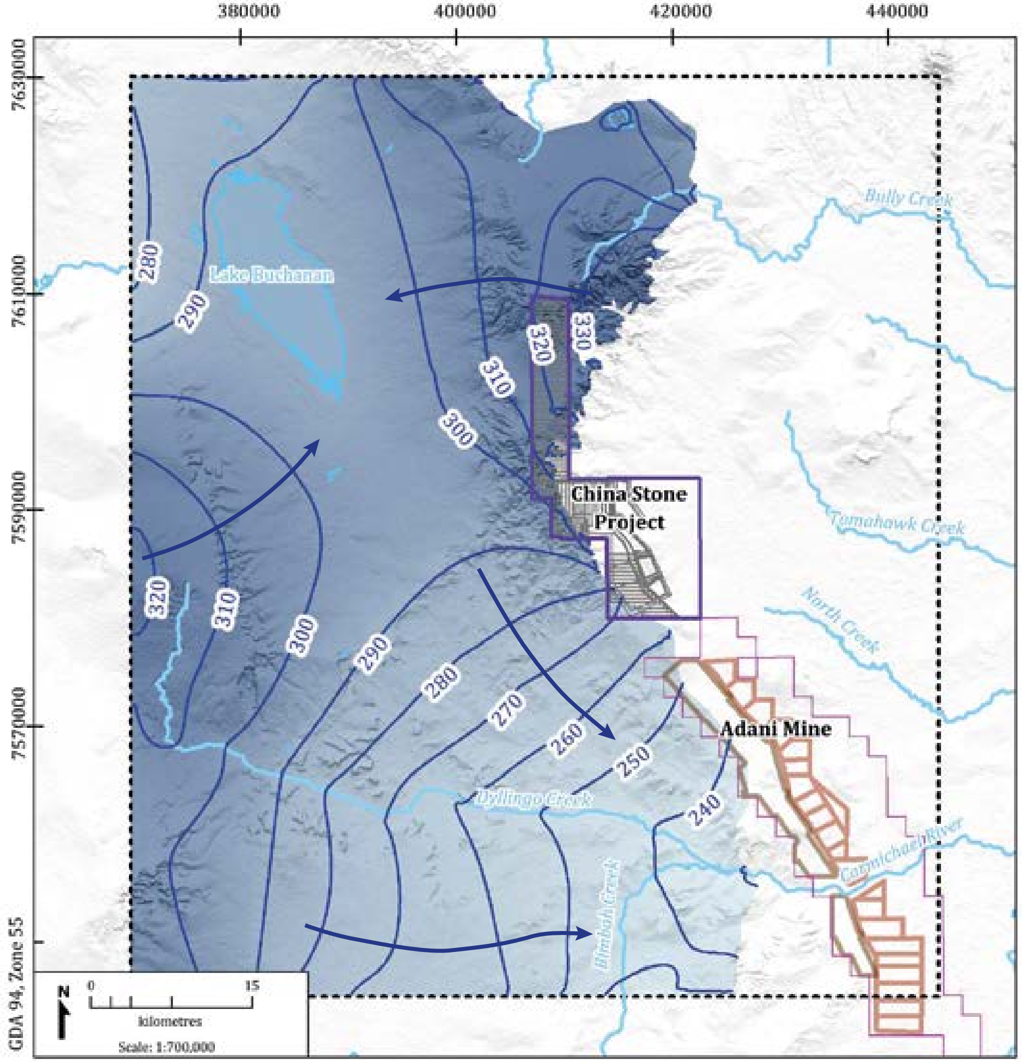
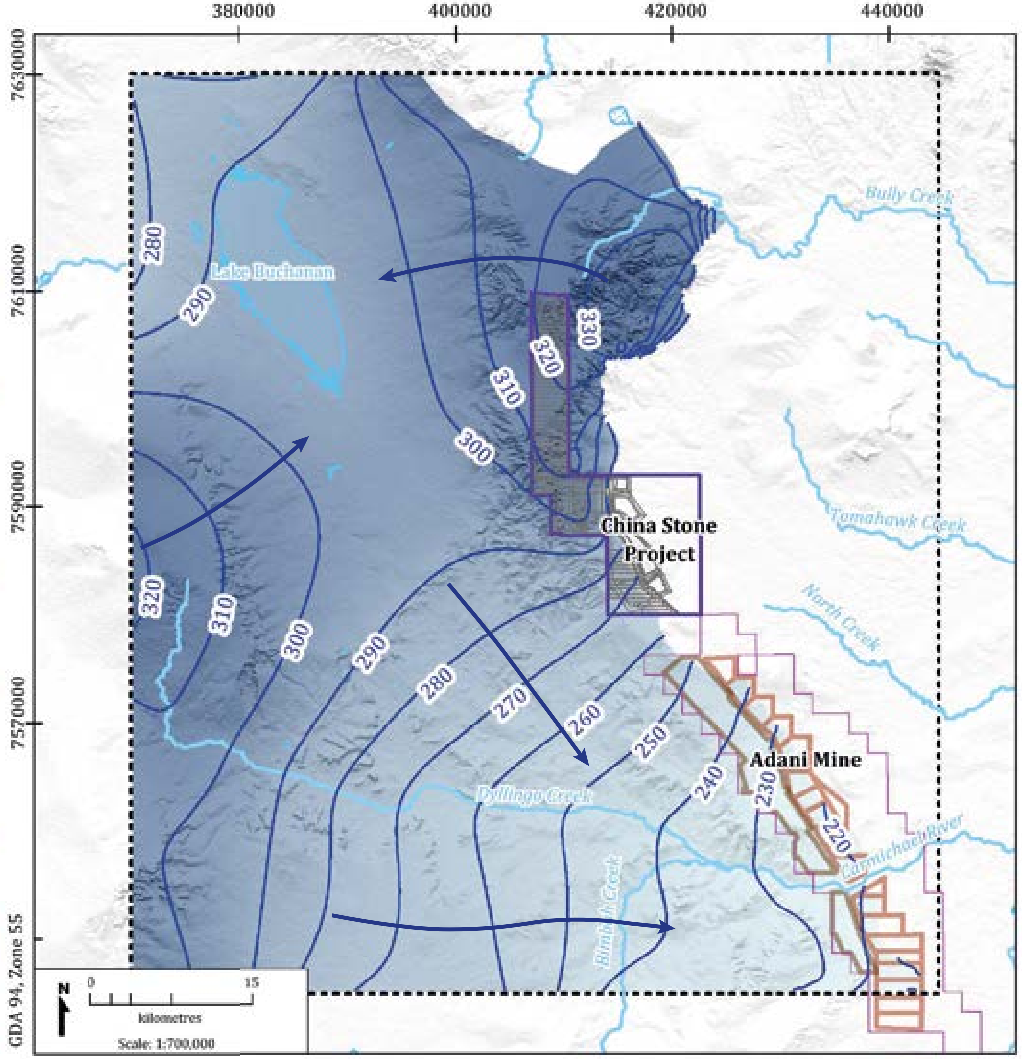
Modelled Steady State Heads - Clematis Sandstone (Layer 5)



Modelled Steady State Heads - Rewan Formation (Layer 8)



LEGEND:

- Steady state groundwater contour (mAHD)
- Major Drainage
- Model extent
- Project site
- Proposed China Stone mine
- Groundwater flow direction

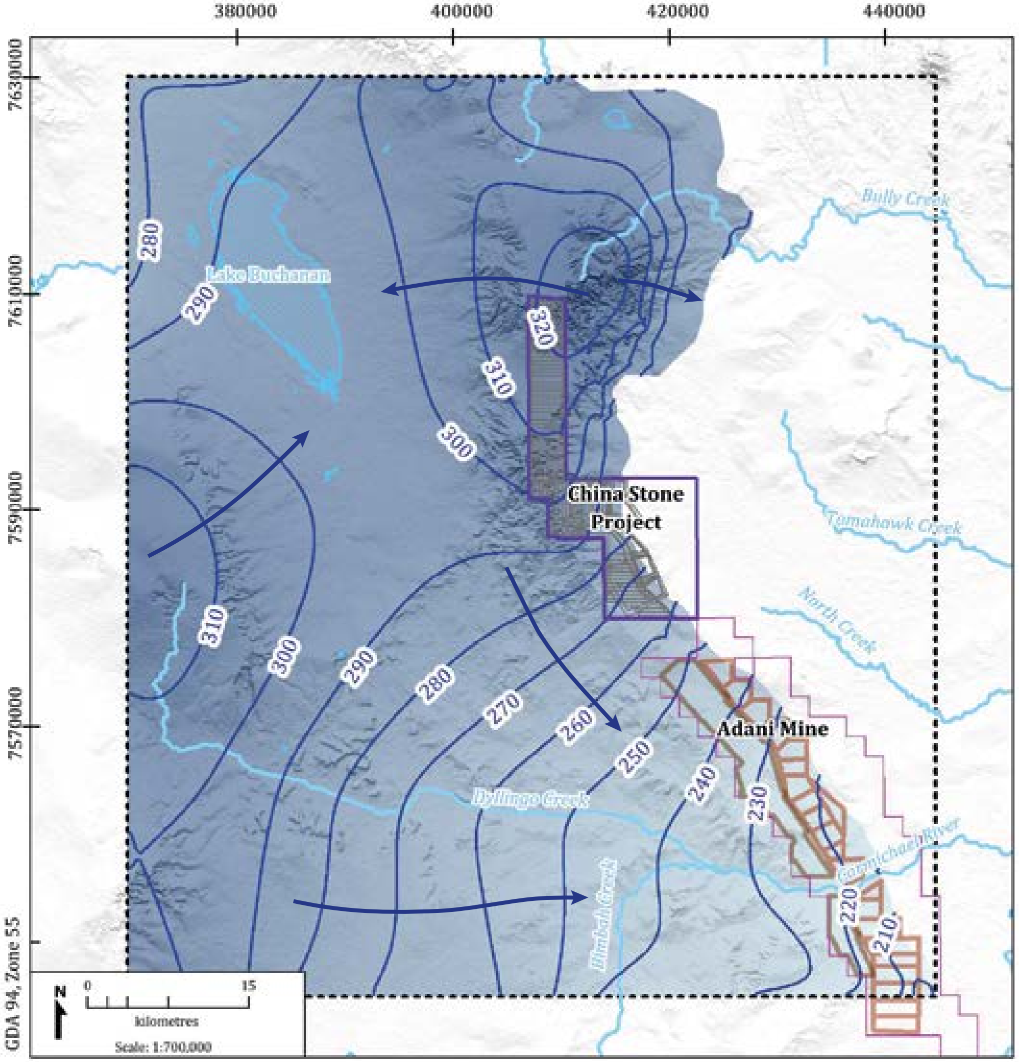
Project China Stone (G1587)
Appendix D - Modelling

Steady State Heads
Layer 5 and Layer 8

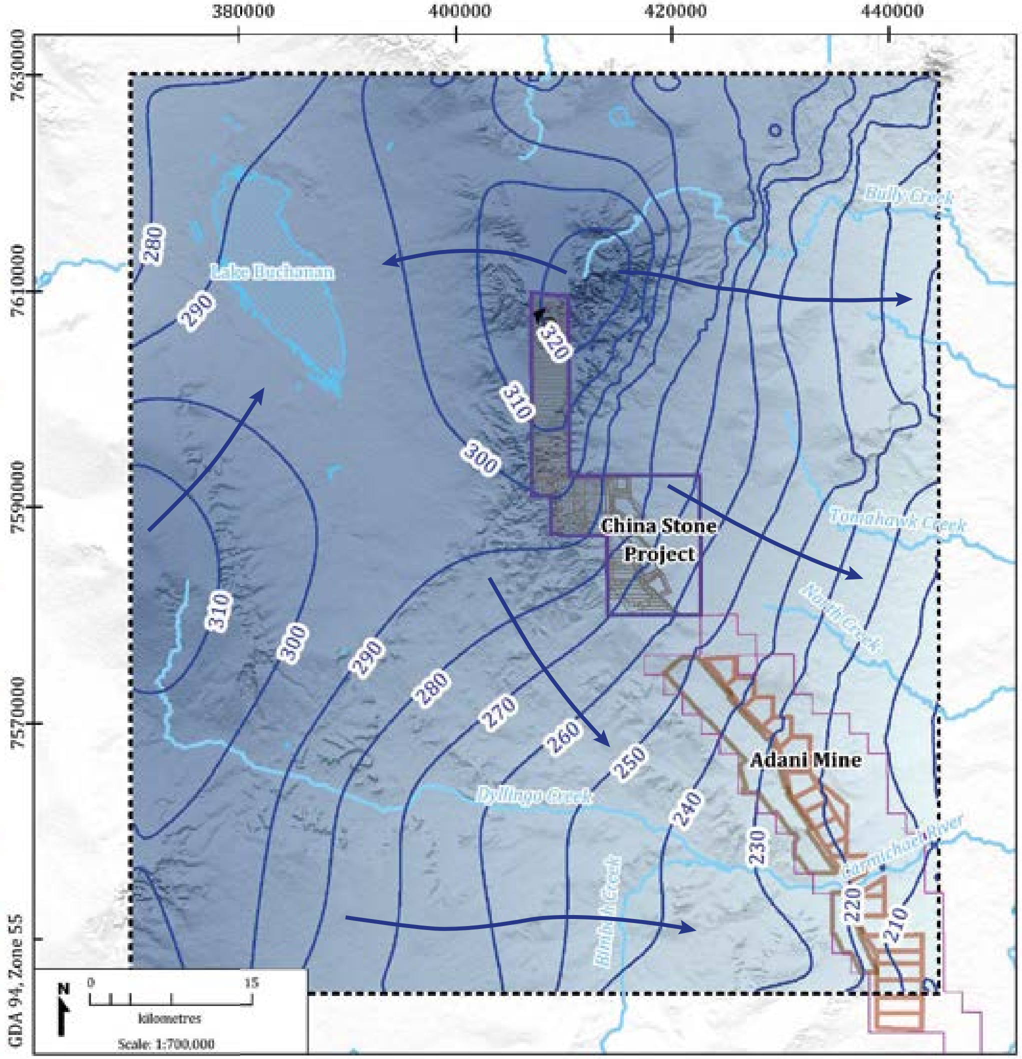
DATE:
24/6/2015

FIGURE No:
B-7

Modelled Steady State Heads - AU Seam (Layer 10)



Modelled Steady State Heads - Joe Joe Group (Layer 17)



LEGEND:

- Major Drainage
- ▭ Model extent
- ▭ Project site
- ▭ Proposed China Stone mine
- → Groundwater flow direction

Project China Stone (G1587)
Appendix D - Modelling

Steady State Heads
Layer 10 and Layer 17

DATE:
25/6/2015

FIGURE No:
B-8

The heads reflect the groundwater flow regime prior to commencement of any mining within the model domain. The figures show a groundwater mound under Darkies Range with influence of the break of slope recharge is also evident in the heads. The mound under Darkies Range divides groundwater flow into easterly and westerly directions. Consistent with the conceptual model groundwater flows towards the east similar to the topography, and towards the west to Lake Buchanan.

B1.3.4 Hydraulic parameters

Table B-5 summarises the calibrated hydraulic conductivity of the hydrostratigraphic units in the model domain.

Table B 5 Model layer hydraulic parameters

Model layer	Lithology	Horizontal hydraulic conductivity (Kxy) (m/day)	Vertical hydraulic conductivity (Kz) (m/day)
1	Quaternary sediments	$1.50 \times 10^{+1}$	**6.50**
1 - 16	Weathered host rock	1.28×10^{-4} - 3.20×10^{-1}	**5.42×10^{-6} - 4.00×10^{-1}**
2	Tertiary sediments	1.25×10^{-1}	**6.24×10^{-2}**
3	Ronlow Beds	1.00×10^{-1}	**2.42×10^{-2}**
4	Moolayember Formation	6.50×10^{-2}	**3.25×10^{-2}**
5	Clematis Sandstone	5.00×10^{-2}	**1.26×10^{-2}**
6	Dunda Beds	1.08×10^{-3}	**2.16×10^{-5}**
7/8	Rewan Formation	2.79×10^{-3}	**6.01×10^{-5}**
9	Betts Creek Beds interburden	1.12×10^{-4}	**1.12×10^{-6}**
10	Betts Creek Beds A Seam	4.20×10^{-4} - 4.21×10^{-2}	**4.20×10^{-4} - 4.21×10^{-2}**
11	Betts Creek Beds interburden	5.00×10^{-4}	**6.93×10^{-5}**
12	Betts Creek Beds B Seams	2.70×10^{-4} - 2.27×10^{-2}	**2.38×10^{-4} - 2.00×10^{-2}**
13	Betts Creek Beds interburden	1.48×10^{-3}	**5.20×10^{-4}**
14	Betts Creek Beds C Seam	5.00×10^{-5} - 1.31×10^{-2}	**5.00×10^{-6} - 1.31×10^{-3}**
15	Betts Creek Beds interburden	4.67×10^{-4}	**6.85×10^{-6}**
16	Betts Creek Beds D Seam	7.00×10^{-5} - 8.71×10^{-3}	**7.00×10^{-6} - 8.71×10^{-4}**
17	Betts Creek Beds underburden	5.00×10^{-5}	**2.50×10^{-5}**
18	Joe Joe Group	5.00×10^{-5}	**2.50×10^{-5}**

Figure B 9 compares the distribution of the hydraulic conductivity (horizontal) field measurements against the geometric mean in the model. It shows graphically the match between the field data and the model developed for the project and by GHD (2013) for the Carmichael Coal Mine Project.

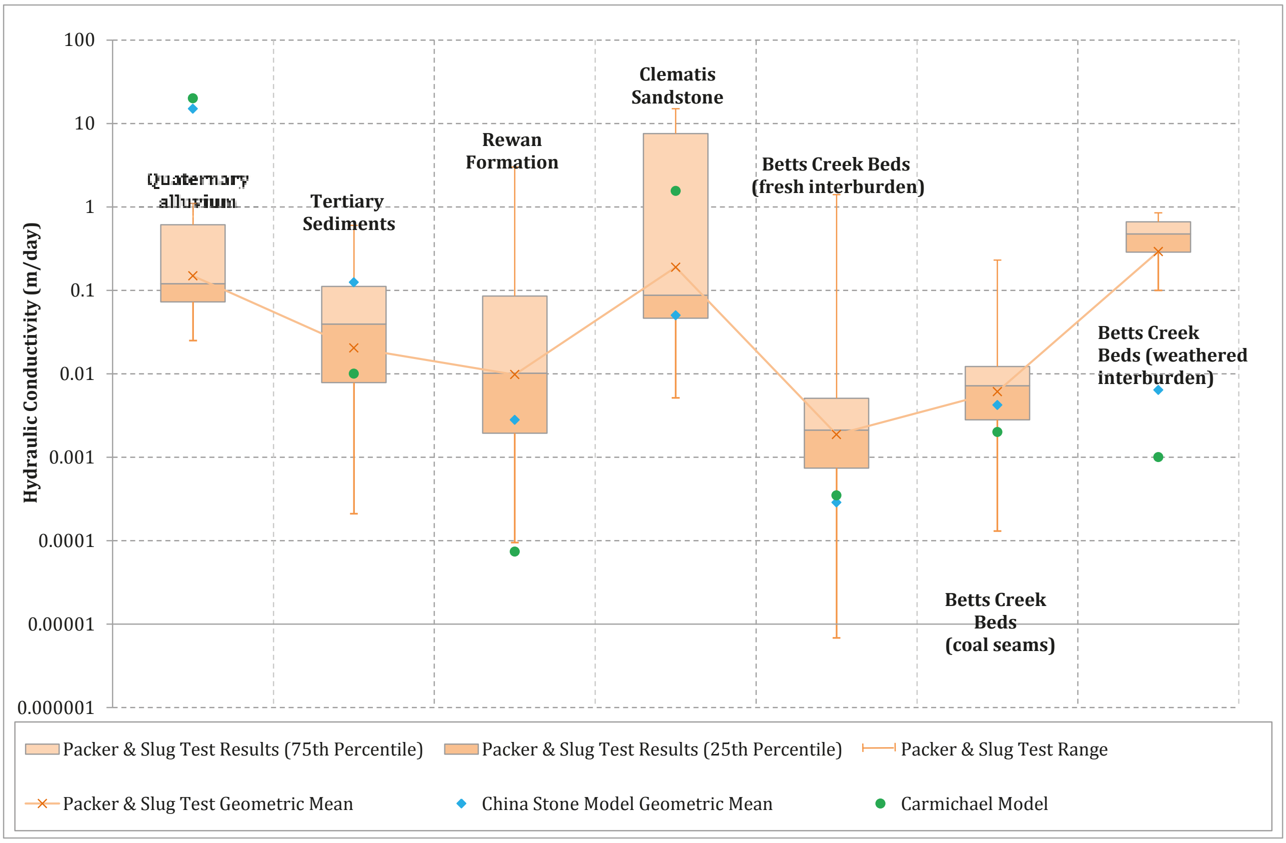


Figure B 9 Distribution of horizontal hydraulic conductivity – modelled and observed

Figure B 9 highlights the natural variability in hydraulic conductivity within fractured porous rocks, which vary across orders of magnitude. The calibrated hydraulic conductivity for each unit generally falls within the range of the field measurements. The exception is the modelled hydraulic conductivity for the Quaternary sediments and the weathered rock regolith that falls outside of the range of available field data, in both the project and Carmichael models. There is limited field data for both units; however, as these layers are generally unsaturated at the project site, the calibrated value is not considered to significantly influence the predictions.

All values for the Tertiary, Triassic and Permian units falls within the range of field data results. There is no available field data for the Moolayember Formation, therefore it was assumed to be 0.07 m/day, which is considered conservative given the properties of the unit. Similarly, no field data was available for bores screened in the Ronlow Formation, which primarily acts as an aquifer. Therefore a hydraulic conductivity of 0.1 m/day is reasonable. This unit is some 27 km from the proposed mining areas and therefore, the impacts from the project are not expected to be sensitive to uncertainties in the hydraulic properties at this distance.

B1.3.5 Water budget

The mass balance error, that is, the difference between calculated model inflows and outflows at the completion of the steady state calibration was 0.02%. This value indicates that the model is stable and achieves an accurate numerical solution. Table B-6 summarises the water budget for the steady state model.

Table B 6 Model budgets

Parameter	In (ML/day)	Out (ML/day)	In - Out (ML/day)
Rainfall recharge	4.38	0	4.38
River	79.44	17.30	62.14
General head	95.10	109.85	-14.76
Evapotranspiration	0	51.72	-51.72
Total	178.91	178.87	0.04
Error (%)			0.02

The water budget indicates that recharge to the groundwater system within the model averages 84 ML/day with approximately 17 ML/day being discharged via surface drainage, and 52 ML/day is lost to evapotranspiration in areas where the water table is within 2 m of the land surface.

B1.3.6 Composite model sensitivities

Sensitivity analysis evaluates the effect of changing individual model parameters on model results and indicates the uncertainty in the estimates of model parameters. The sensitivity of simulated heads to parameters was assessed to aid model calibration. The relative composite sensitivity (RCS) was calculated as outlined by Doherty (2010):

$$s_i = (J^tQJ)^{0.5}b_i/m$$

where: J = Jacobian matrix, derivatives of simulated heads at observations with respect to the i^th^ parameter in vector b.

Q = cofactor matrix, a diagonal matrix with the elements being the squared observation weights.

b_i = i^{th} parameter value in vector b.

m number of observations that have non-zero weights.

The composite sensitivity values were calculated during the PEST calibration process for the steady-state model and were converted to RCS as shown in Figure B 10.

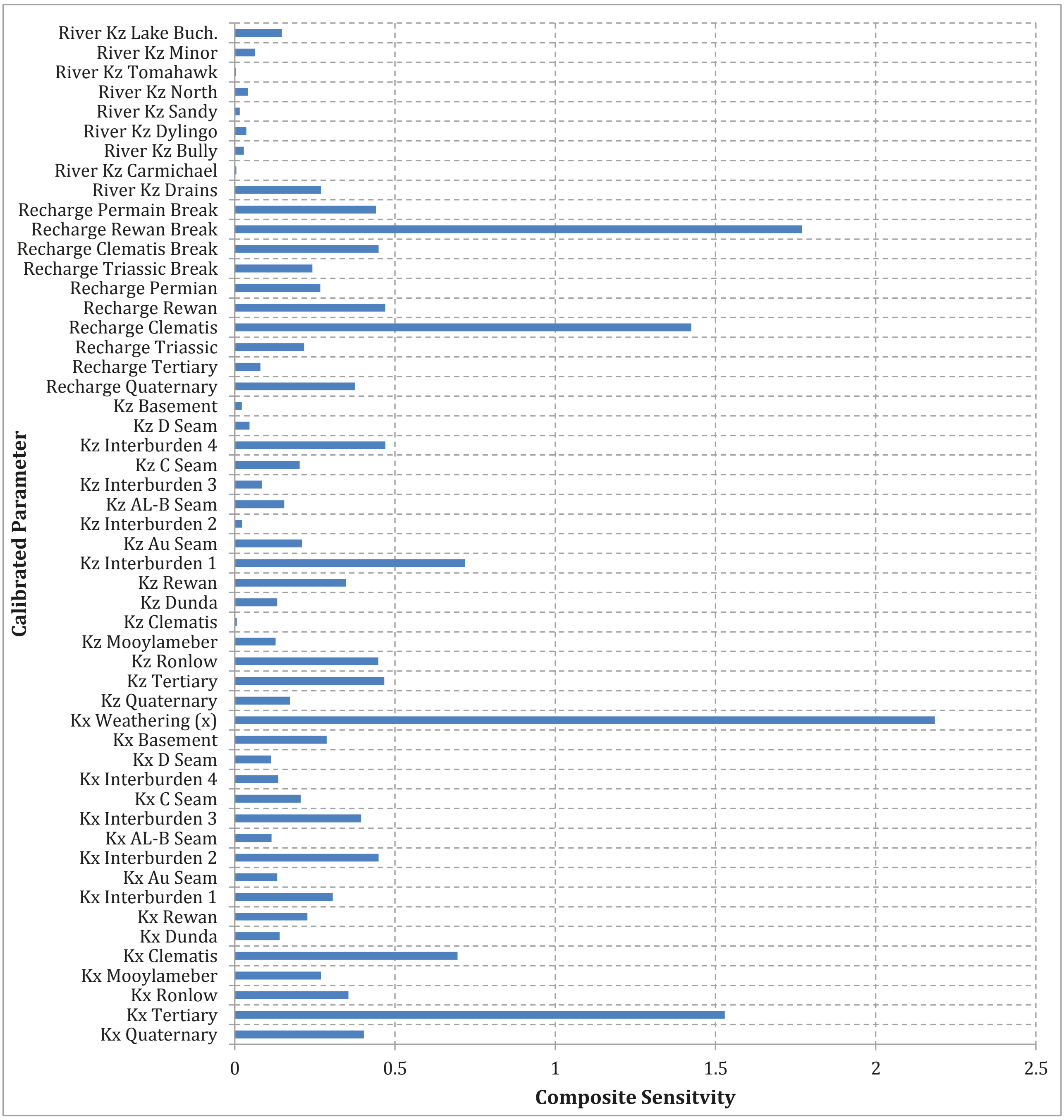


Figure B 10 Model composite sensitivity

The reason for scaling the sensitivity data is that sensitivities are typically presented in the units of the simulated value divided by the units of the parameter (Hill and Tiedeman, 2007). For example, the parameter units may consequently be in m^3/day, m/day or mm/yr and the method of scaling (composite sensitivity) provides sensitivity measures with the same units and a method for comparison. RCS is therefore a dimensionless statistic and is a measure of the composite changes in model outputs that are incurred by a change in the value of the parameter. That is, whether the model calibration is sensitive to an input parameter such as hydraulic conductivity or recharge. This statistic can be used to assess the relative sensitivity of model parameters given the set of observations used in the model.

RCS can reflect the total amount of information provided by the observations for the estimation of each parameter (Hill and Tiedeman, 2007). Generally, if the RCS of a parameter is greater than one, the model is sensitive to this parameter and the model observations have provided enough information to estimate the parameter with greater certainty. Figure B 9 shows that parameters with a RCS greater than 1 are:

- recharge to the Rewan Formation at the break of slope;
- recharge to the Clematis Sandstone;
- factor applied to the hydraulic conductivity to represent weathering of host rock; and
- hydraulic conductivity of the Quaternary / Tertiary sediments.

Where parameters have a low RCS, the model calibration is less sensitive to these, yet there is greater uncertainty associated with them and they are likely to contribute more to the uncertainty of the model predictions. In this case, the predictive uncertainty has been guided by this sensitivity analysis within the constraints of the model calibration statistics.

B1.3.7 Transient verification

The model was not calibrated to transient water level data as monitoring was undertaken during a drought period with limited significant recharge events occurring during the baseline period for the EIS. Instead, the transient water level records were used to verify the model could replicate water levels measured in the monitoring bore network installed for the project. The model ran with fortnightly stress periods for the period of available water level data from November 2011 to February 2014. Recharge was applied to the groundwater model according to averages from BOM station 36010.

Appendix D-1 contains hydrographs showing the measured and simulated water levels for 26 of the site-based bores and vibrating wire sensors used for the verification. The hydrographs show that the model generally simulates the muted response to recharge events recorded in the monitoring bores.

B1.3.8 Model confidence level classification

Barnett *et al* (2012) developed a system to classify the confidence-level for groundwater models. Models are classified as either Class 1, Class 2 or Class 3 in order of increasing confidence (i.e. Class 3 has the highest level of confidence). Several factors are considered in determining the model confidence level:

- available data;
- calibration procedures;
- consistency between calibration and predictive analysis; and
- level of stresses.

The model has achieved and generally exceeded the criteria considered for a Class 1 model, and in some respects it has met a number of the criteria for a Class 2 confidence level classification. The following aspects are where the modelling approach does not achieve the Class 2 level:

- a transient calibration has not been undertaken;
- transient predictions are made when calibration is in steady state only; and
- the model has not been reviewed.

While the guidelines indicate that the model is a Class 1 the other aspects that have been satisfied for Class 1 also satisfy the Class 2 key indicators, meaning that the model is very close to being a Class 2. Because of this, the model is considered to be fit-for-purpose as an impact assessment model.

One reason the model remains a Class 1 model is the lack of transient calibration, and hence the prediction period is greater than 10 times the calibration period. From the limited transient data available it is apparent that there is little seasonal pattern to the groundwater behaviour, especially with the water table deeper than 60 m below ground level in some areas. It could be argued that the steady state calibration has addressed the long term groundwater behaviour. While this means that storage characteristics of the aquifer have not been calibrated, this limitation has been addressed in the sensitivity analysis undertaken.

B2. Predictive simulations

B2.1 Time slices

A simplified iterative approach was applied involving running the model in short time frames (time "slices" of six months) to represent the mining process and changes in hydraulic conductivity. The 50 years of mining was subdivided into 100 stages, each six months in length. At the end of each stage, the model was stopped and the last predicted groundwater levels for the simulation were used as starting points for the next simulation stage. At this point in time, changes in aquifer parameters resulting from the effects of the subsidence of material into the mined panel and the formation of a goaf above the panel, were applied. The vertical hydraulic conductivity was increased using the log-linear ramp function. A Fortran computer program was written to undertake the "stop-start" nature of the staged simulation. This program defined the active cell drains on a biannual basis and applied pre-defined rules for the changes in aquifer parameters and finally generated each of the time slices. This approach has been used successfully for a large number of impact assessment flow models.

B2.2 Mine drainage

During the transient run, drain cells were used to simulate the effect of the proposed mine and other mines in the area. A nominally high drain conductance of 100 m^2/day was applied to the drain cells and the elevation of the mined seam floor was used as the drain level. For the open cut mines, the drain cells were set in all layers from the mined seam to the surface. For the underground mines, the drain cells were only set in the mined layer.

The model represented mining using the drain (DRN) package. This required setting 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 term. In the case of the project, the drain cells used to simulate mining were set to a reference level at the base of each mined coal seam (i.e. base of AU, B, C and D coal seams). A nominally high drain conductance rate (approximately 100 m^2/day) was used to facilitate free drainage conditions from the strata and ensure the groundwater level was lowered to the reference level, hence dewatering the coal seam.

B2.1 Storage properties

Table B-7 summarises the values of specific storage and specific yield adopted in the model.

Table B 7 Model layer hydraulic parameters

Model layer	Lithology	Specific yield Sy (%)	Specific storage Ss (m^{-1})
1	Quaternary sediments	10	**1 x 10^{-3}**
1 - 16	Weathered host rock	1	**2 x 10^{-4}**
2	Tertiary sediments	5	**2 x 10^{-4}**
3	Ronlow Beds	1	**2 x 10^{-5}**
4	Moolayember Formation	1	**2 x 10^{-5}**
5	Clematis Sandstone	1	**2 x 10^{-5}**
6	Dunda Beds	1	**2 x 10^{-5}**
7/8	Rewan Formation	1	**2 x 10^{-5}**
9	Betts Creek Beds - interburden	1	**2 x 10^{-5}**
10	Betts Creek Beds - A Seam	1	**2 x 10^{-5}**
11	Betts Creek Beds – interburden	1	**2 x 10^{-5}**
12	Betts Creek Beds - B Seam	1	**2 x 10^{-5}**
13	Betts Creek Beds – interburden	1	**2 x 10^{-5}**
14	Betts Creek Beds - C Seam	1	**2 x 10^{-5}**
15	Betts Creek Beds – interburden	1	**2 x 10^{-5}**
16	Betts Creek Beds - D Seam	1	**2 x 10^{-5}**
17	Betts Creek Beds – interburden	1	**2 x 10^{-5}**
18	Joe Joe Group	1	**2 x 10^{-5}**

Note: *Parameters used in the model are conservative estimates using a combination of limited field data, hydrogeological expertise and knowledge of the region.*

B2.2 Underground mining

The proposed underground mining schedule extends over 45 years and comprises the Northern and Southern Undergrounds mining the A and D seams, and C seams respectively. Longwall mining progresses from south to north. Mining commences in the D and C seams, while mining of the overlying A seam commences three years later, slightly offsetting the mining areas at any time.

The EIS Subsidence Report assessed the potential height of continuous cracking induced above the subsiding longwall panels. The EIS Subsidence Report concluded that:

- an upper bound height of 120 m for continuous fracturing associated with single seam extraction; and
- a conservative continuous fracturing height of 180 m above the upper seam extracted in dual seam mining areas.

The majority of the Northern Underground involves dual seam mining (A and D Seams). This area is overlain by the Clematis Sandstone. The interburden thickness between the A Seam and the base of the Clematis Sandstone is variable with a minimum thickness of 115 m to 120 m on the western side of the fault, and 140 m to 160 m on the downthrown eastern side. The height of connective cracking would therefore intersect the overlying Clematis Sandstone.

The model represented the continuous cracking above the longwall panels by increasing the vertical hydraulic conductivity (Kz) of each overlying layer intersected by cracking. The vertical hydraulic conductivity was calculated for each layer by increasing the base value by a factor ranging from 10 to 1000 times. Table B 8 details the factor used to calculate the vertical conductivity of each affected layer. Increases to Kz were based upon a log-linear factor ramp function, with, upper and lower limits applied to ensure a hydraulic connectivity was maintained throughout the cracking zone.

In addition, where the cracking height is predicted to intersect the base or part of a geological unit (e.g. the Clematis Sandstone above the Northern Underground), the entire geological unit has been assumed to be continuously cracked. That is to say, that each intersected geological unit has been modelled as cracked across its entire vertical profile, by applying the factored increase in vertical conductivity across the full thickness of the equivalent model layers.

Table B 8 Hydraulic conductivity of fractured zone

Layer	Geology	Value Kz (m/day) (base value)	D Seam mining factor (x)	D Seam mining value Kz (m/day)	A Seam mining factor (x)	A Seam mining value Kz (m/day)
5	Clematis Sandstone	1.26×10^{-2}	1	1.3×10^{-2}	10	1.3×10^{-1}
6-7	Rewan Formation	6.01×10^{-5}	1	6.0×10^{-5}	20	1.2×10^{-3}
8	Rewan Formation	6.01×10^{-5}	10	6.0×10^{-4}	50	3.0×10^{-3}
9	Betts Creek Beds interburden	1.12×10^{-6}	1000	1.1×10^{-3}	5000	5.6×10^{-3}
10	Betts Creek Beds A Seam	5.00×10^{-5}	50	2.5×10^{-3}	500	2.5×10^{-2}
11	Betts Creek Beds interburden	6.93×10^{-5}	100	6.9×10^{-3}		
12	Betts Creek Beds B Seams	8.72×10^{-5}	100	8.7×10^{-3}		
13	Betts Creek Beds interburden	5.20×10^{-4}	100	5.2×10^{-2}		
14	Betts Creek Beds C Seam	1.00×10^{-5}	500	5.0×10^{-3}		
15	Betts Creek Beds interburden	6.85×10^{-6}	1000	6.9×10^{-3}		
16	Betts Creek Beds D Seam	1.00×10^{-5}	1000	1.0×10^{-2}		

Figure B 11 shows the relationship between the change in Kz and height above D and C Seam, and above A Seam.

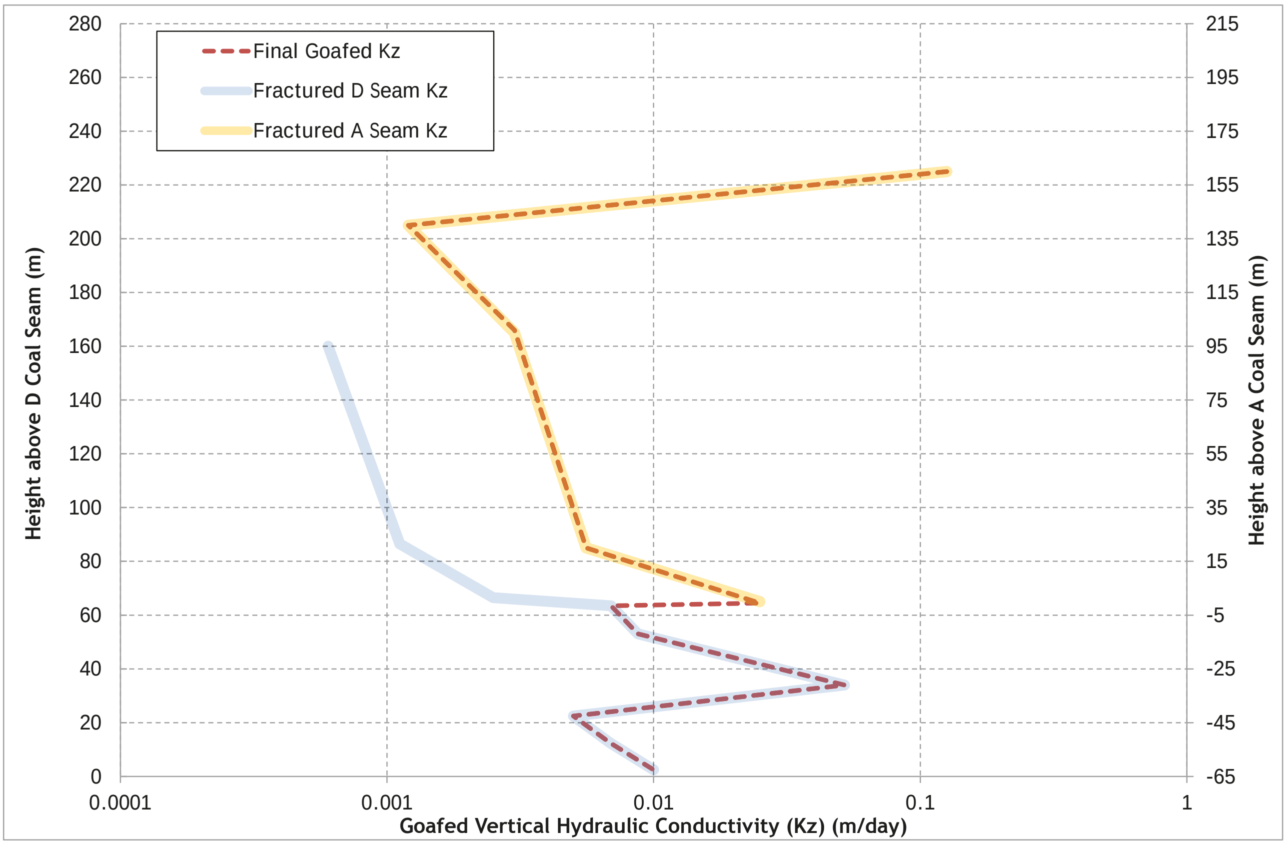


Figure B 11 Fractured vertical hydraulic conductivity by height above coal

The hydraulic conductivity of the fractured zone above the D and C Seams was adjusted in the model to follow the trend shown in black, with units overlying the A seam adjusted according to the trend shown in yellow. The combined values after both seams are mined are shown in green.

B2.3 Opencut mining

The project includes 30 years of truck and shovel mining from the surface to the base of the B coal seam. Within the open cut areas, the model changed the hydraulic properties and recharge rates to represent development of the spoil piles on a two yearly basis.

B3. Sensitivity analysis

A sensitivity analysis was carried out to assess the response of the model to varying input parameters. The objective of the sensitivity analysis was to rank the input parameters in terms of their influence on the predicted results. The model parameters were adjusted to encompass the range of likely uncertainty in key parameters.

The following perturbations were assessed in the sensitivity analysis:

- ±1 order of magnitude change in horizontal and vertical hydraulic conductivity (K) of all units;
- ±50% change in horizontal and vertical hydraulic conductivity (K) of overburden;
- ±100% change in the specific yield (S) of all units in the model;
- ±50% change in specific yield (S) of overburden;
- ±1 order of magnitude change in the specific storage (S) of all units in the model;
- ±100% change in the specific storage (S) of overburden;
- ±1 order of magnitude change in the rainfall recharge (Rch) rate across the model domain; and
- ±50% change in the rainfall recharge rate (Rch) on the overburden.

In addition, a specific sensitivity analysis was undertaken to test the influence of the geological fault on the predicted results. The perturbations investigated in this analysis comprised:

- a low permeability fault plane running through the underground mining area, represented with the Horizontal Flow Barrier Package (HFB) set with a conductance term of $1x10^{-7}$ m^2/day; and
- a highly permeable fault plane represented by a zone of cells 75m x 75m cells set to the same hydraulic conductivity and storage as the Clematis Sandstone (K/S).

These perturbations represent extremes in the potential behaviour of the fault (i.e. groundwater conduit or groundwater flow barrier).

The following sections present the results of these sensitivity analyses in terms of their influence on groundwater inflow (seepage) predictions, groundwater level changes (zone of drawdown/depressurisation).

B3.1 Mining area seepage

Figure B 12 to Figure B 14 show the sensitivity of the predicted seepage rate to changing the parameters in the model.

The predicted seepage was most sensitive to changes in the storage parameters of the host hydrostratigraphic units during the open cut mining phase. Increasing the storage by one order of magnitude more than doubled the maximum predicted seepage peaks from 15 ML/day to 40 ML/day. Conversely reducing the storage by one order of magnitude effectively halved the maximum predicted seepage peak.

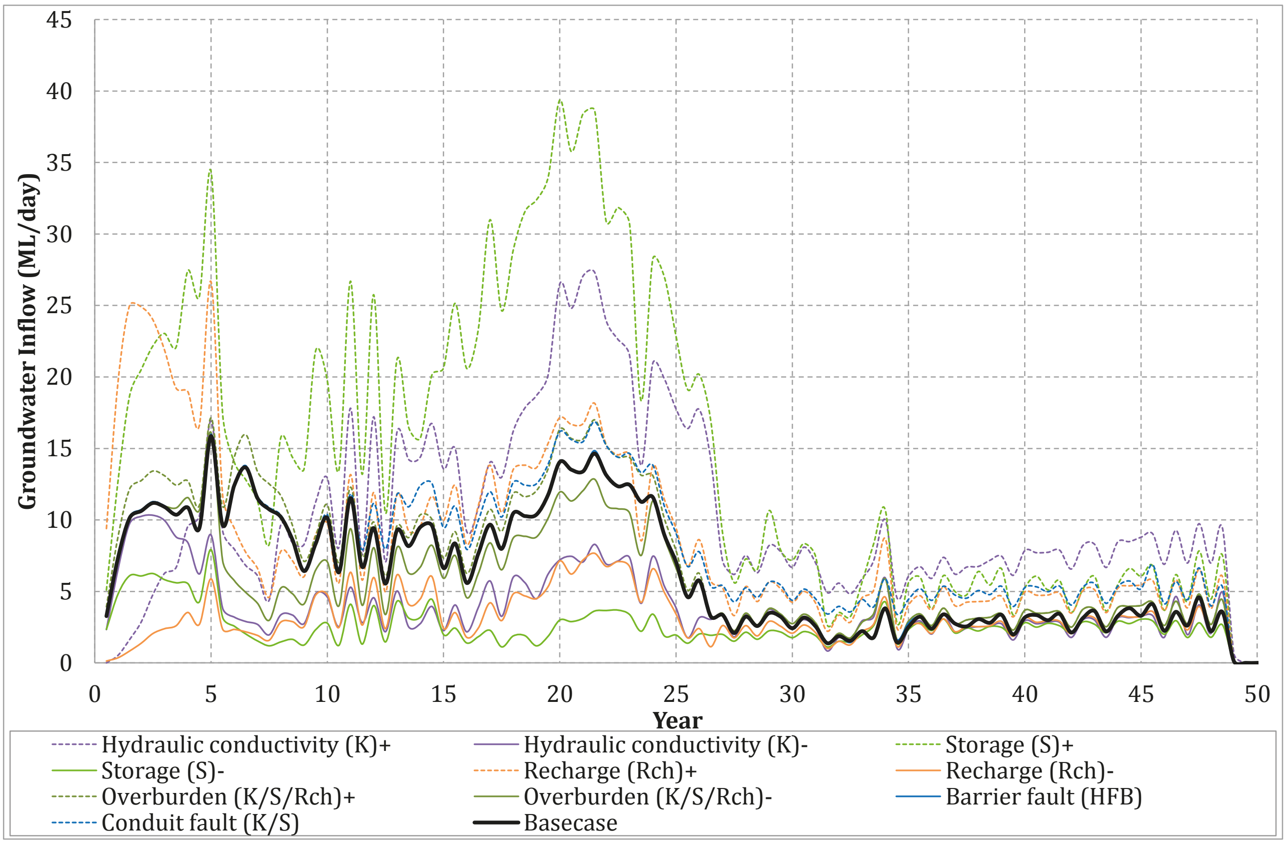


Figure B 12 Sensitivity of total mine inflows

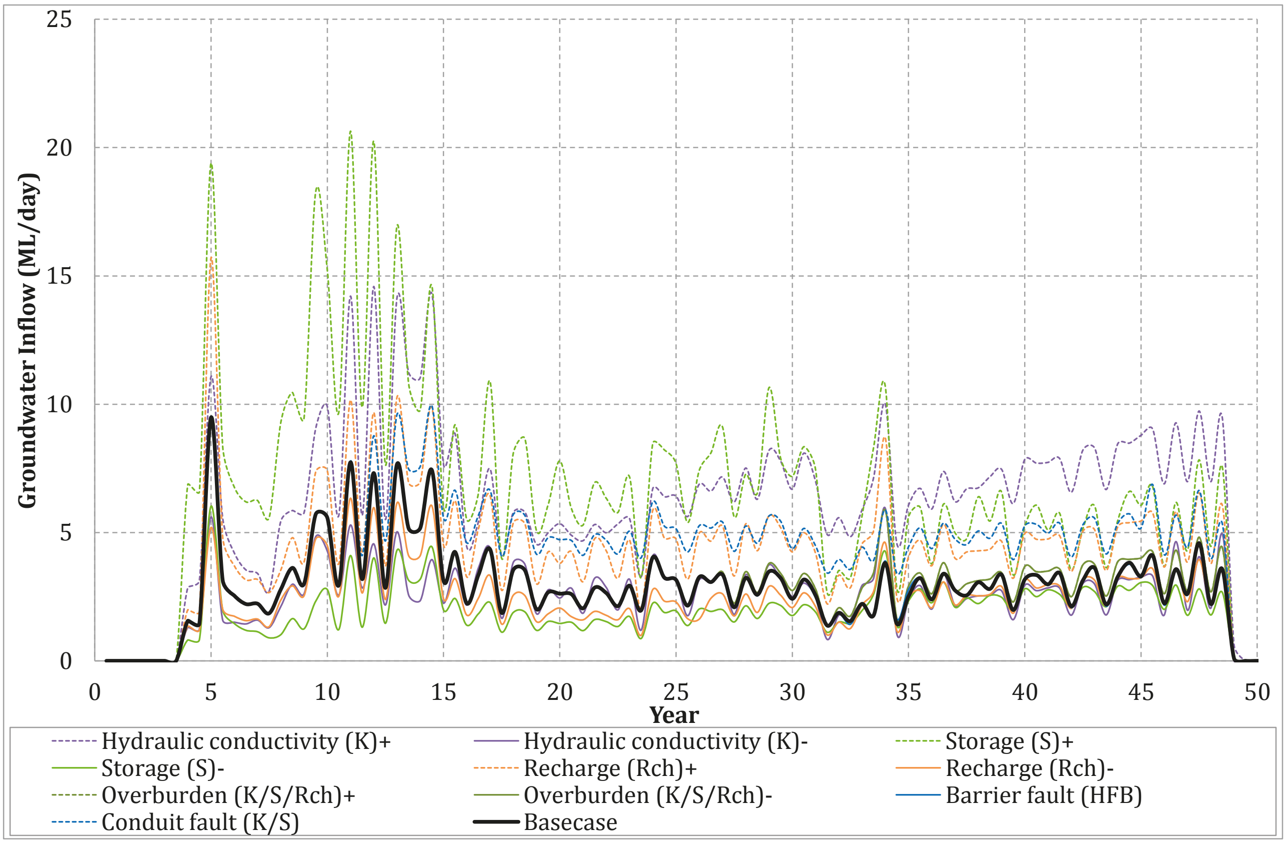


Figure B 13 Sensitivity of underground longwall mine inflows

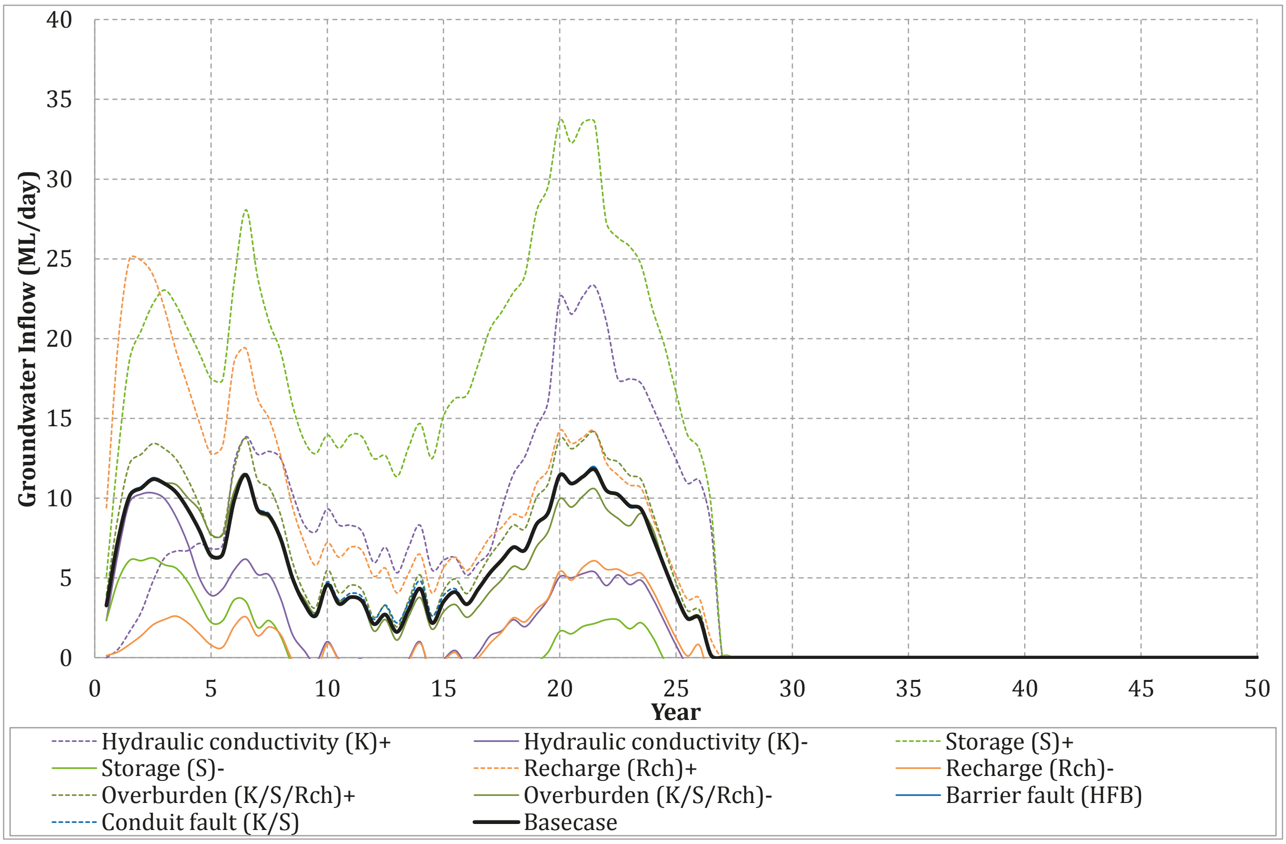


Figure B 14 Sensitivity of open cut mine inflows

Introducing a permeable fault plane of 75m width increased the inflow to the underground mine by approximately 2 ML/day. A similar increase in the inflow to the underground mine occurred when the recharge rate increased by an order of magnitude. Decreasing the permeability of the fault plane resulted in no discernible increase in the predicted inflow to the underground mine above the base case. When interpreting the scenario used to represent a permeable fault it is important to understand it is considered completely improbable because the model represented the faults as being a single cell wide, which is 75 m, with a hydraulic conductivity equivalent to porous sandstone. In our experience faults in Australian coal mining regions do not generate expansive zones of fractured rock either side of the slippage plane, and the zone where hydraulic properties are changed is typically only a few metres wide, thus a 75 m width is likely to be a gross over-representation of the fault plane.

Reducing hydraulic conductivity, storage and recharge had only a marginal impact, reducing the inflow to the underground mine by 0.5 ML/day or less.

Table B 9 shows how changing the model parameters influences the overall model error (as represented by the SRMS and the mine seepage). It shows that the magnitude of the changes to the hydraulic conductivity and recharge made during the sensitivity analysis reduced the ability of the model to match measured water levels and degraded the calibration statistics. This highlights the changes made during the sensitivity analysis are likely to represent conservative extremes for these parameters.

The exception was the changes made to represent the fault as a barrier or conduit to groundwater flow. These changes did not significantly affect the calibration statistics.

Table B 9 Summary results of sensitivity analysis

Parameter	Steady state SRMS (%)	Maximum mine seepage (MLpa)
Basecase	7.7	5,072
Hydraulic conductivity (K)+	12.4	9,471
Hydraulic conductivity (K)-	15.8	3,705
Storage (S)+	-	13,548
Storage (S)-	-	2,227
Recharge (Rch)+	16.6	9,118
Recharge (Rch)-	12.0	2,631
Overburden (K/S/Rch)+	-	5,886
Overburden (K/S/Rch)-	-	4,895
Conduit fault (K/S)	7.8	5860
Barrier fault (HFB)	7.8	5118

B3.2 Zone of depressurisation

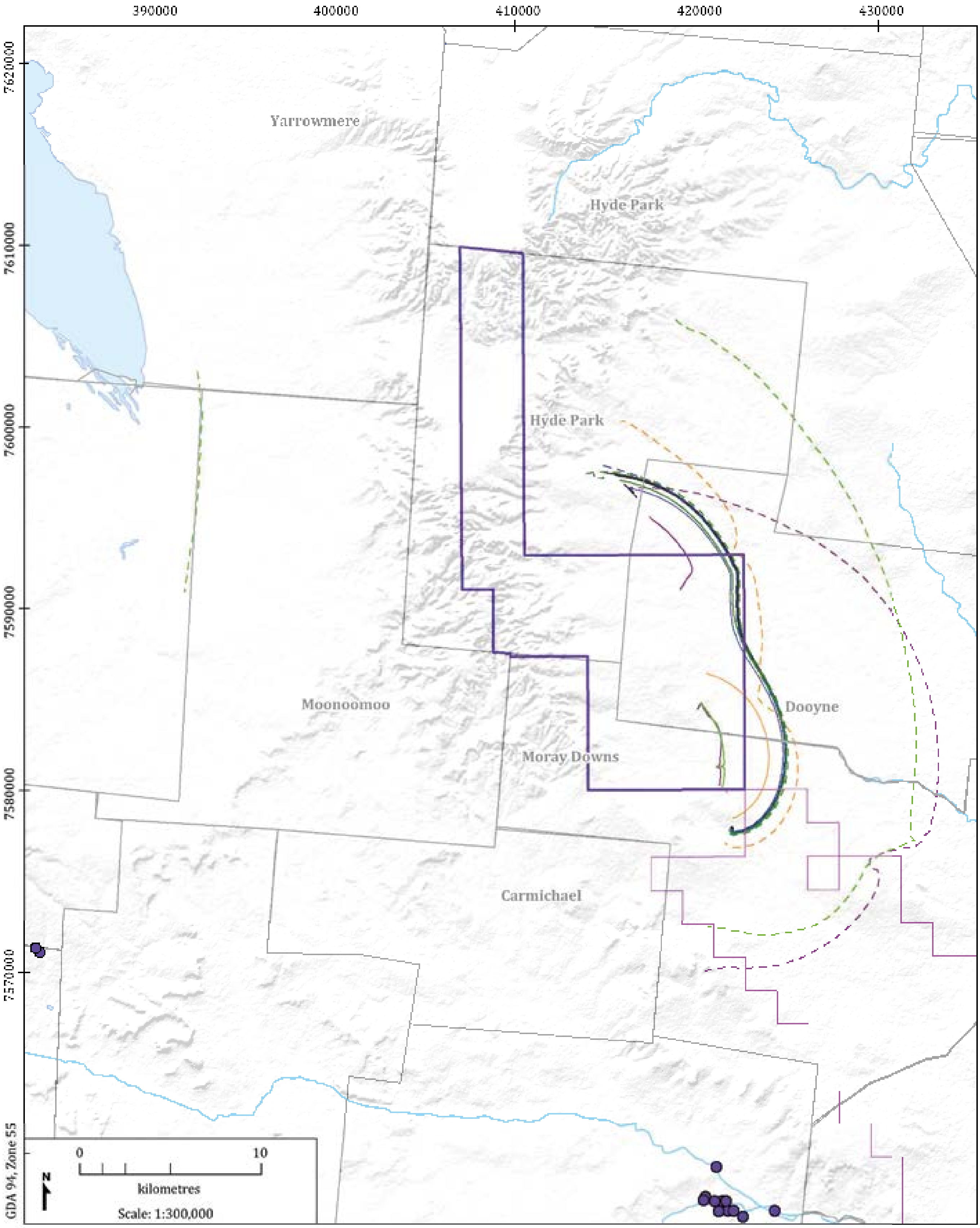
The sensitivity analysis assessed the changes to the zone of depressurisation in the Tertiary sediments and Clematis Sandstone during the operations and post mining phases.

Figure B 15 and Figure B 16 show the maximum groundwater depressurisation throughout the mine life, and Figure B 17 and Figure B 18 show groundwater depressurisation post mining.

The results show that groundwater depressurisation is most sensitive to changes in storage and hydraulic conductivity during the mining phase and post mining.

The properties of the fault have less influence than storage and hydraulic conductivity on the depressurisation during the mining and post mining phases.

Figure B 15 to Figure B 18 show that maximum drawdown extents do not extend to any springs located to the south or south-west of the project and therefore we can conclude with high confidence that the project will not affect these features.



LEGEND:

- Project site
- Carmichael Coal Mine Project
- Major drainage
- ● Springs
- ☐ Cadastre
- Lake

Sensitivity - 1m contour

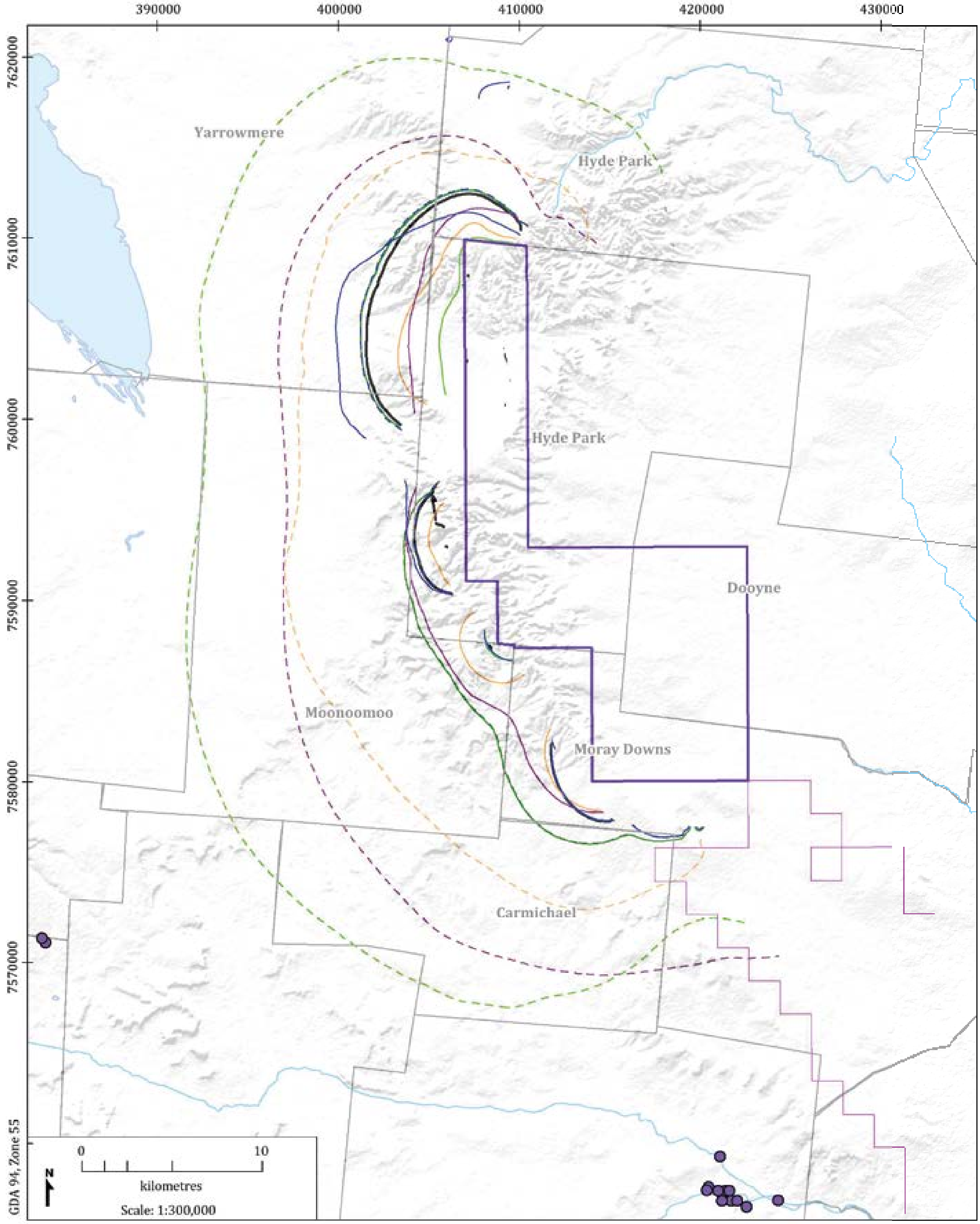
- Basecase
- Hydraulic conductivity (K) +
- Hydraulic conductivity (K) -
- Conduit fault (K/S)
- Barrier fault (HFB)
- Recharge (Rch) -
- Recharge (Rch) +
- Storage (S) +
- Storage (S) -
- Overburden (K/S/Rch)+
- Overburden (K/S/Rch) -

Project China Stone (G1587)

Sensitivity of maximum zone of depressurisation during mining - Tertiary sediments

DATE: 24/6/2015

FIGURE No: **B-15**



LEGEND:

— Project site
— Carmichael Coal Mine Project
— Major drainage
● Springs
☐ Cadastre
▨ Lake

Sensitivity - 1m contour

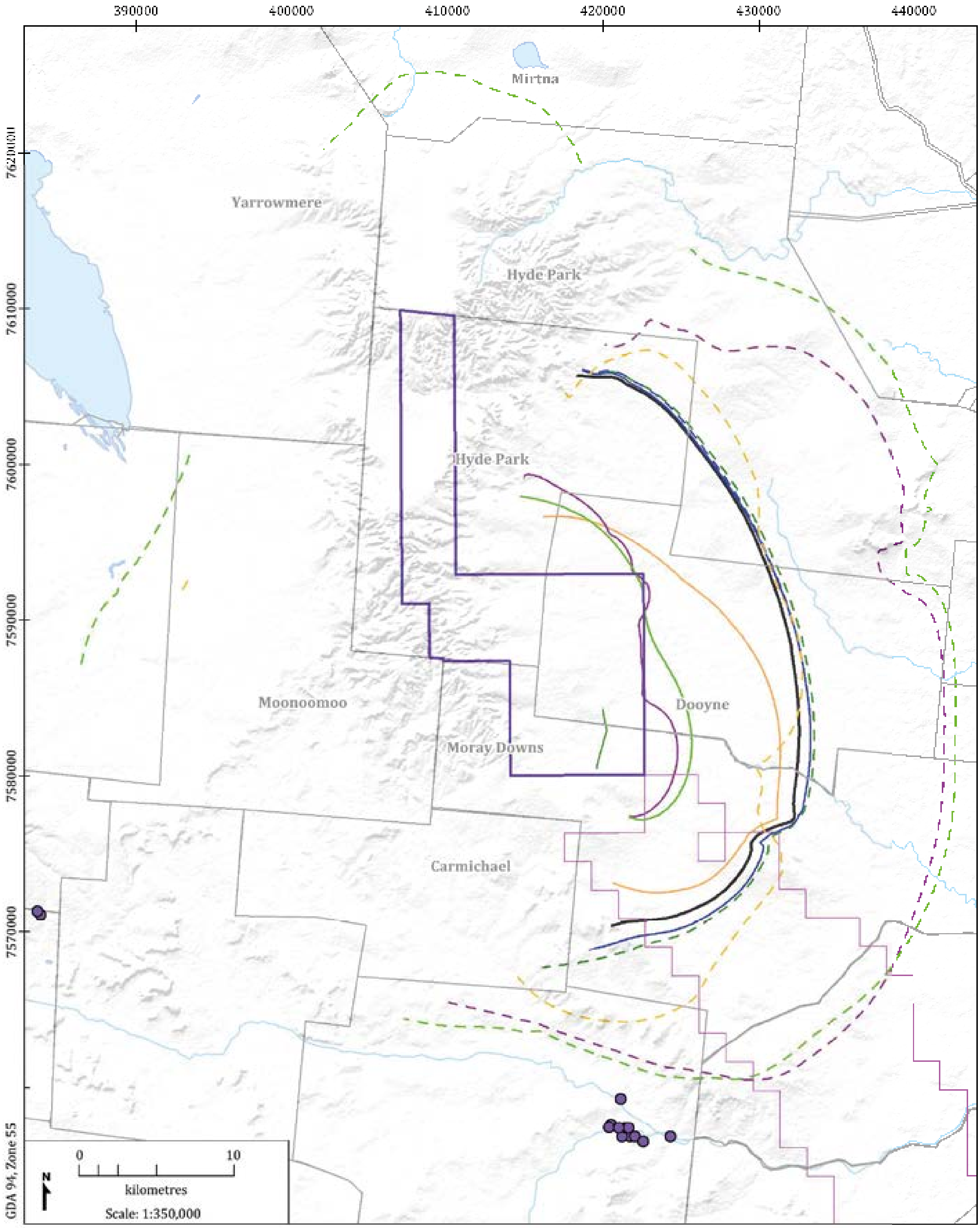
— Basecase
- - Hydraulic conductivity (K) +
— Hydraulic conductivity (K) -
- - Conduit fault (K/S)
— Barrier fault (HFB)
— Recharge (Rch) -
- - Recharge (Rch) +
- - Storage (S) -
— Storage (S) +
- - Overburden (K/S/Rch) +
— Overburden (K/S/Rch) -

Project China Stone (G1587)

Sensitivity of maximum zone of depressurisation during mining - Clematis Sandstone

DATE: 24/6/2015

FIGURE No: **B-16**



LEGEND:

- Project site
- Carmichael Coal Mine Project
- Major drainage
- ● Springs
- ☐ Cadastre
- Lake

Sensitivity - 1m contour

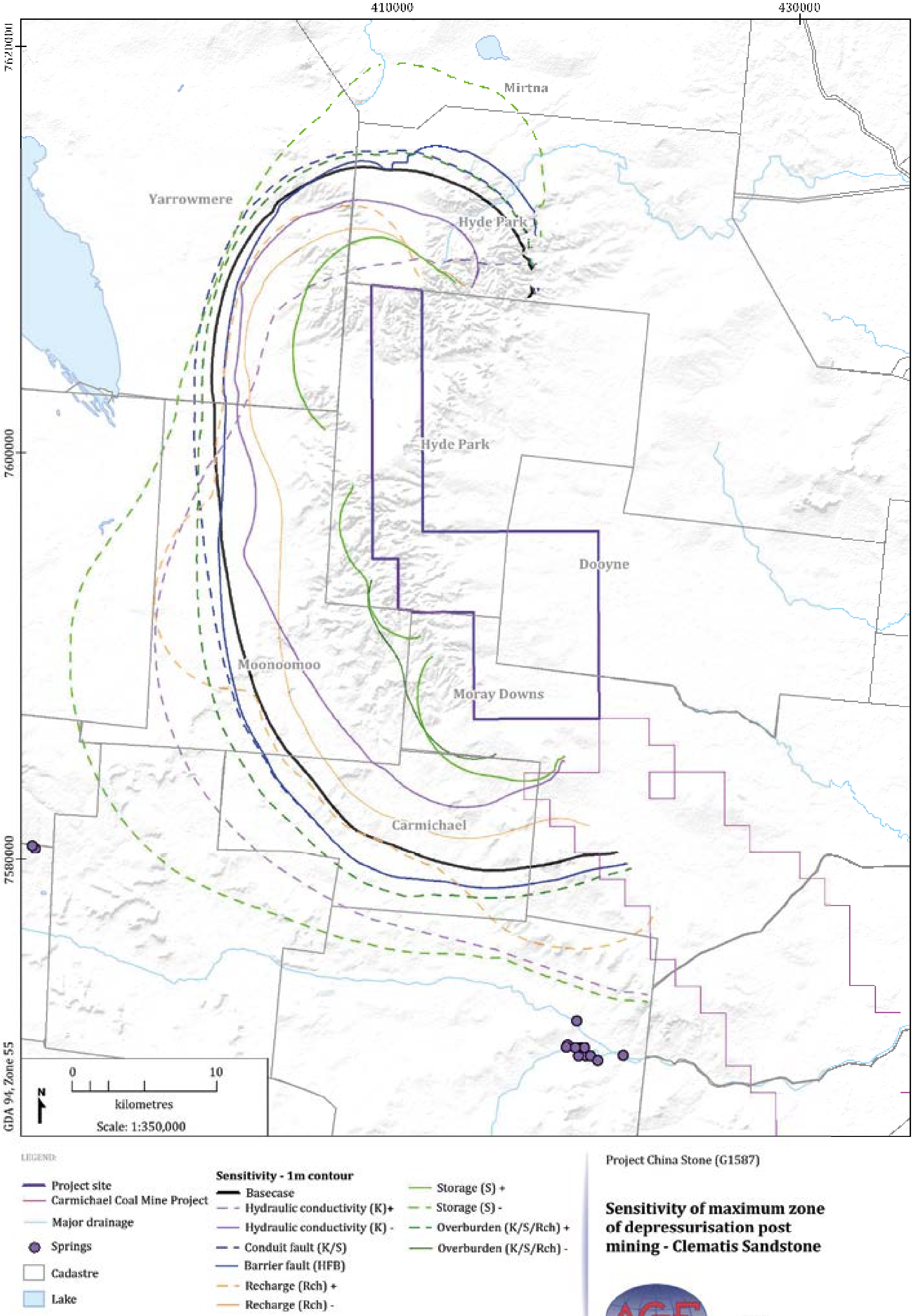
- Basecase
- Hydraulic conductivity (K)+
- Hydraulic conductivity (K)-
- Conduit fault (K/S)
- Barrier fault (HFB)
- Recharge (Rch) -
- Recharge (Rch) +
- Storage (S) +
- Storage (S) -
- Overburden (K/S/Rch) -
- Overburden (K/S/Rch) +

Project China Stone (G1587)

Sensitivity of maximum zone of depressurisation post mining - Tertiary sediments

DATE:
24/6/2015

FIGURE No:
B-17



Project China Stone (G1587)

Sensitivity of maximum zone of depressurisation post mining - Clematis Sandstone

DATE: 24/6/2015

FIGURE No: **B-18**

B3.3 Sensitivity classification

The Murray Darling Basin Modelling Guidelines (Middlemis, 2000) recommends classifying parameter sensitivity by the resultant changes to the model calibration and predictions. The four sensitivity types are as follows:

- Type I: Insignificant changes to calibration and predictions;
- Type II: Significant changes to calibration – insignificant changes to predictions;
- Type III: Significant changes to calibration – significant changes to predictions; and
- Type IV: Insignificant changes to calibration – significant changes to predictions.

Types I and II are of no concern as these sensitivities either have an insignificant impact on model predictions. Type III is only of concern for un-calibrated models. Types I to III are of no concern for the current assessment, as the model developed for the project is a well calibrated, high complexity model.

Type IV is classed as 'a cause for concern' as non-uniqueness in a model input might allow a range of valid calibrations but the choice of value impacts significantly on a prediction (Middlemis, 2000).

There are no Type IV parameters in the model which provides confidence in the range of predictions.

B4. References

Barnett *et al*, (2012) *"Australian Groundwater Modelling Guidelines"*

Doherty, J. (2010) "*PEST: Model-Independent Parameter Estimation, User Manual":* 5th Edition, Watermark Numerical Computing.

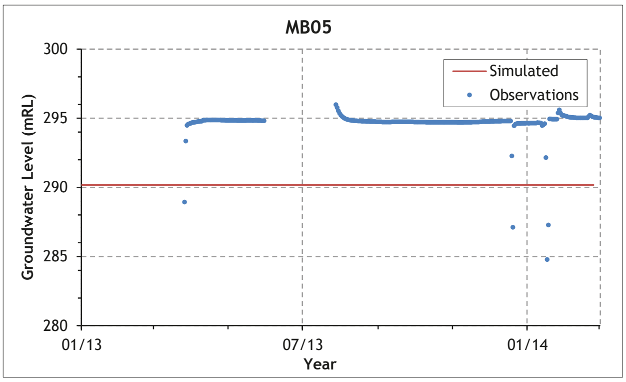
Hill and Tiedeman (2007) *"Effective Groundwater Model Calibration, with Analysis of Data, Sensitivities, Predictions, and Uncertainty"* By Mary C. Hill and Claire R. Tiedeman Published by John Wiley and Sons, New York, in 2007.

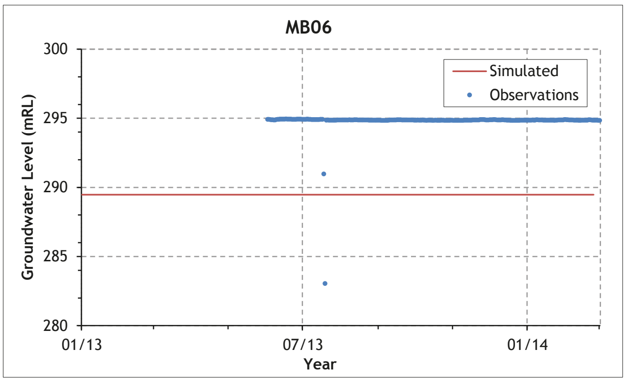
Middlemis H. (2000) "*Groundwater Flow Modelling Guideline*" Murray-Darling Basin Commission.

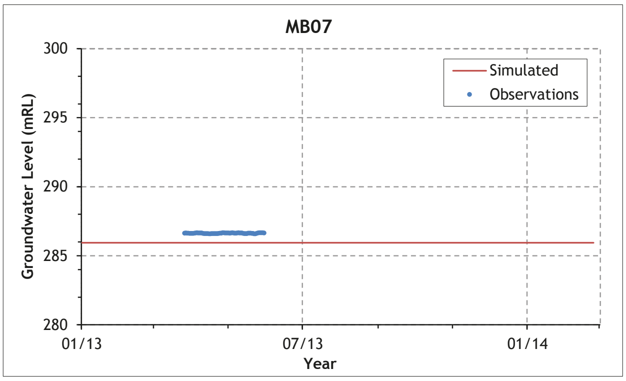
Appendix B-1

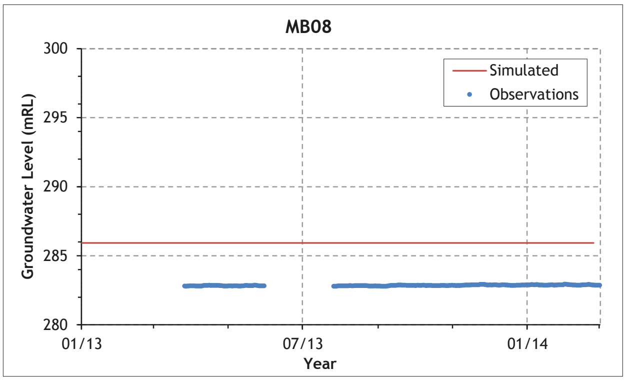
Model verification hydrographs

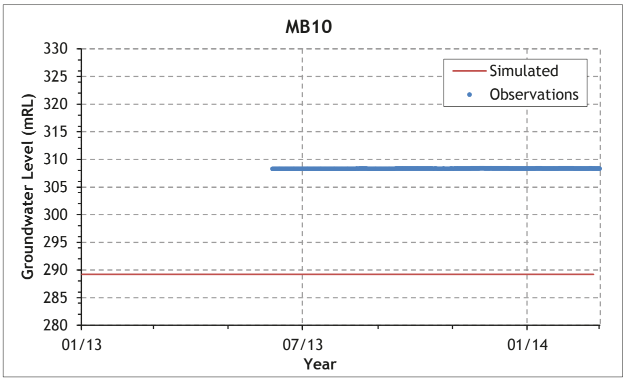
Verification Hydrographs

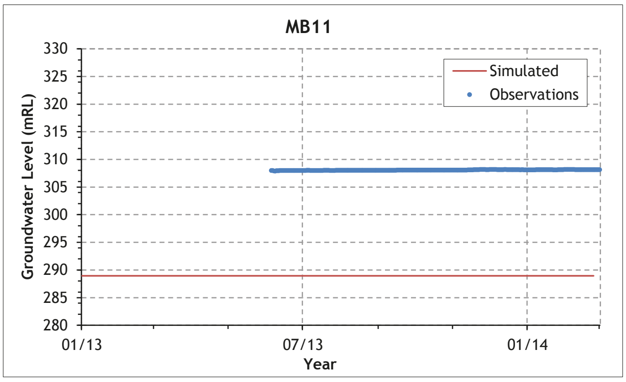


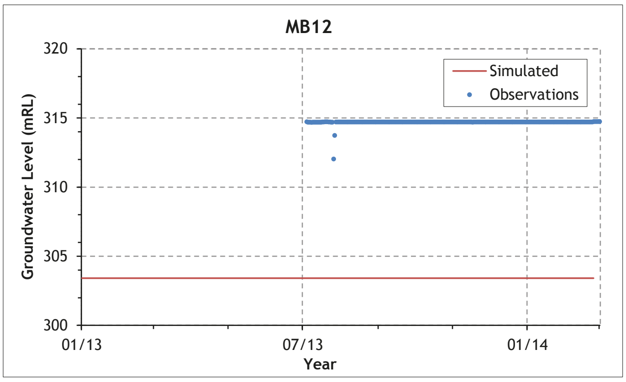


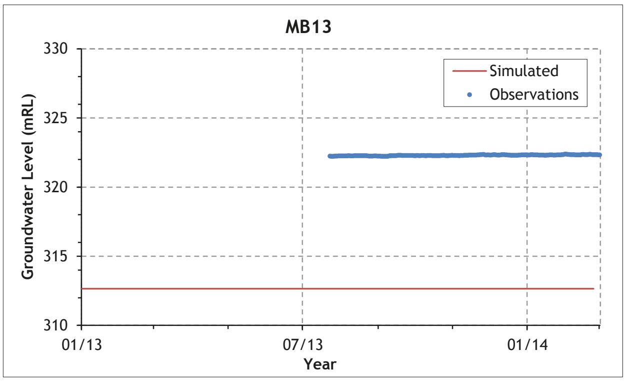




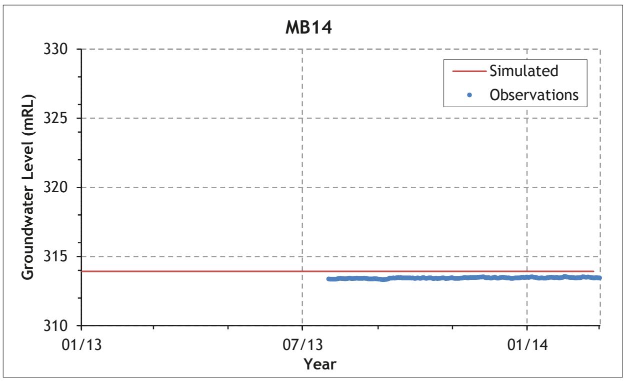


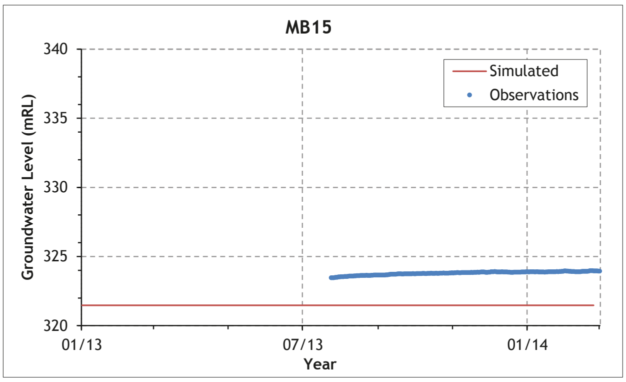


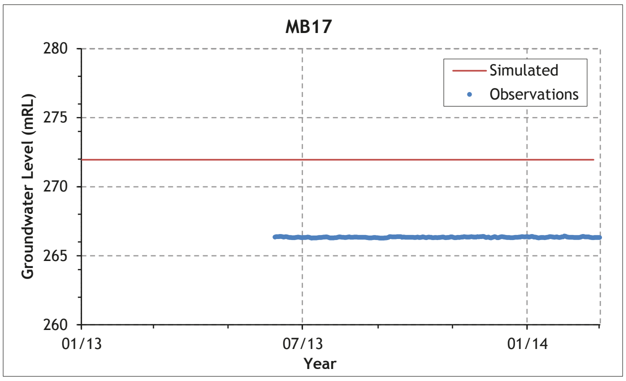


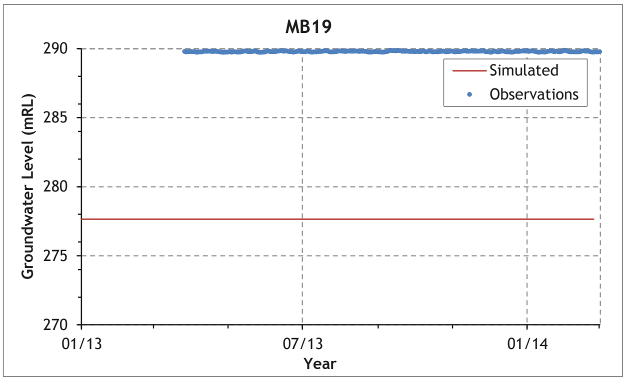


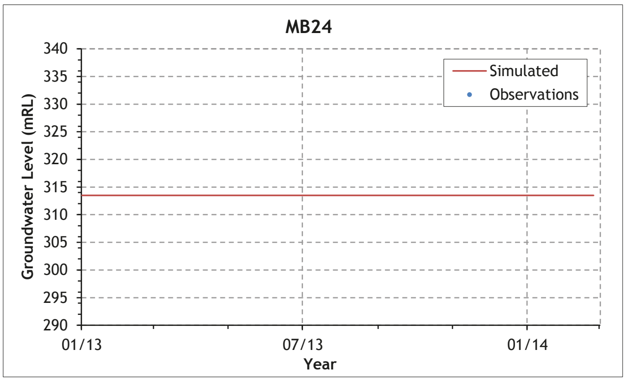
Verification Hydrographs

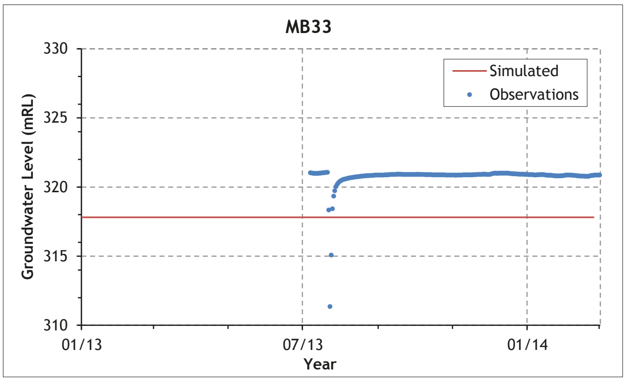


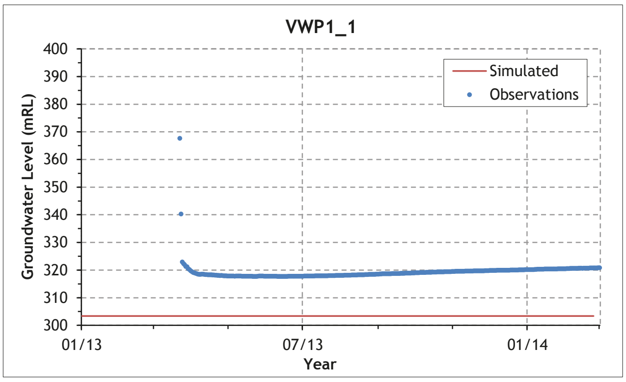


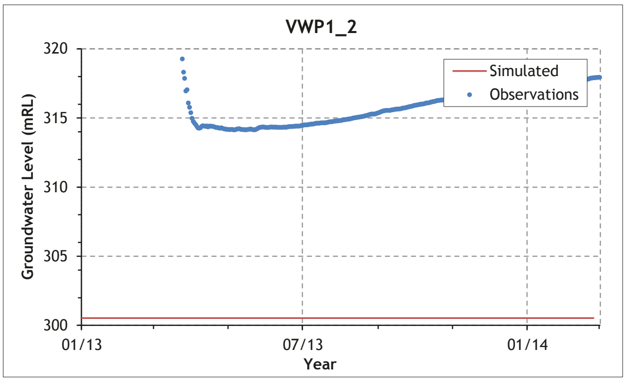




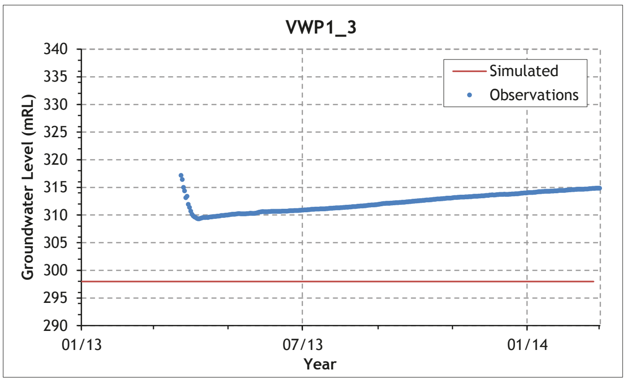


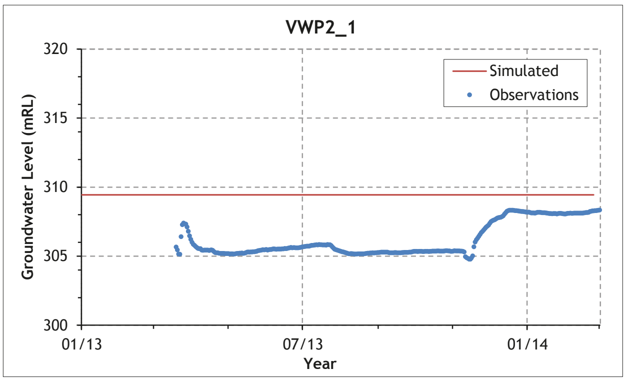


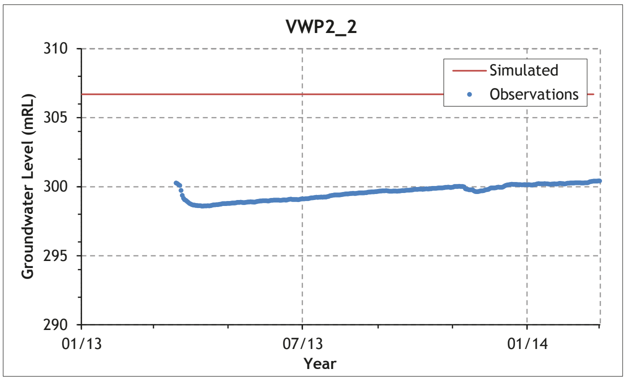


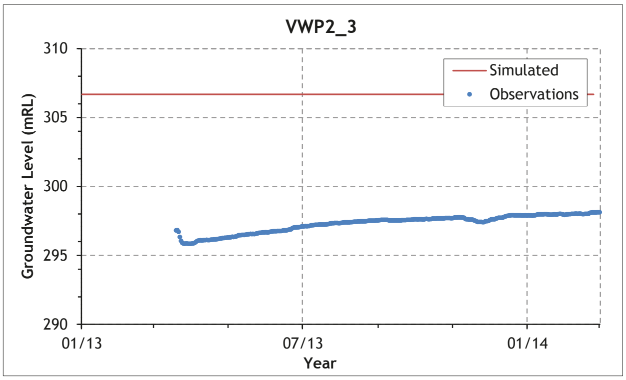


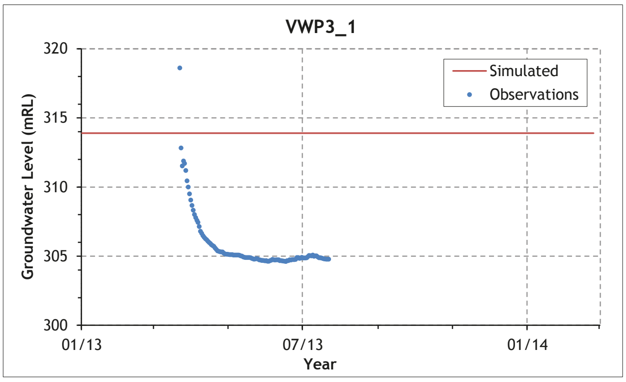
Verification Hydrographs

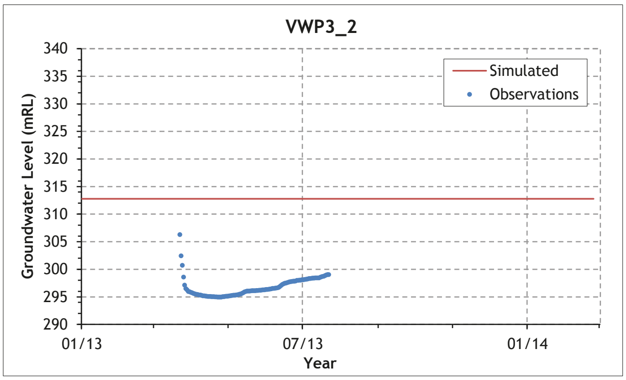


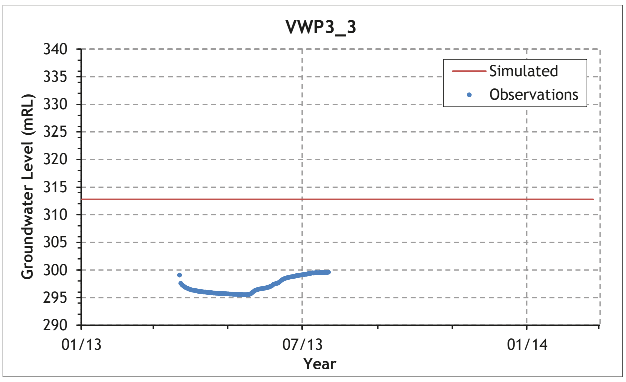


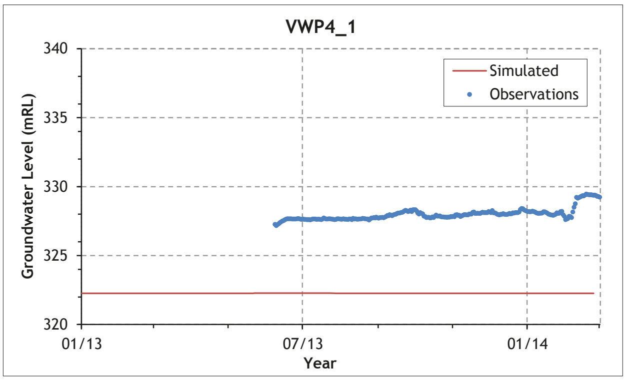












Verification Hydrographs