PROJECT CHINA STONE

Groundwater 12

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12 GROUNDWATER

12.1 INTRODUCTION

This section provides a summary of the key findings of the Environmental Impact Statement (EIS) groundwater assessment undertaken for Project China Stone (the project). The assessment was undertaken by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) and the detailed report is provided in the *Groundwater Report* (Appendix I).

12.2 SCOPE OF WORK AND METHODOLOGY

The scope of work and methodology for the groundwater assessment included:

- Conceptualising the groundwater regime of the project site and surrounding area through:
  - Reviewing relevant geological data including coal mining and coal seam gas exploration drilling logs, petroleum exploration test wells, seismic survey reports and Commonwealth Department of Mineral Resources stratigraphic bore logs;
  - Reviewing a 3D geology model developed by the proponent;
  - Reviewing various groundwater, geotechnical and environmental reports from the project site and the adjacent Carmichael Coal Mine site in order to develop an appreciation of the hydrogeological setting of the area. This included review and analysis of data collected from 62 monitoring bores and 24 vibrating wire piezometers (VWPs) installed at the adjacent Carmichael Coal Mine site. The location of the bores and VWPs is shown on Figure 12-1;
  - Reviewing hydrogeological data held on the Department of Natural Resources and Mines (DNRM) groundwater database for existing water bores;
  - Undertaking a census of private bores in the area to confirm bore locations, usage and water quality;
  - Installing dedicated monitoring bores and VWPs for measuring groundwater levels, quality and hydraulic parameters. A total of 31 monitoring bores and 12 VWPs were installed in the relevant geological units of the project site. The location of the bores and VWPs is shown on Figure 12-1; and
  - Analysing the above listed data and using it to develop a conceptual groundwater model.
- Developing a 3D numerical groundwater flow model (MODFLOW SURFACT) for the project to simulate the existing conditions of the groundwater regime and provide predictions of the potential impacts of future mining activities. The model included hydrogeology (based on the conceptual groundwater model) and the project's proposed open cut and underground mining operations and associated subsidence cracking of subsurface strata.
- Undertaking predictive modelling for the project to assess the scale and extent of mining impacts upon water levels, groundwater users and the surrounding environment during mine operations and post closure.
- Assessing the groundwater impacts of the project and developing feasible mitigation and management strategies in the event of potential adverse impacts being identified. Impacts assessed included groundwater levels, mine inflow and groundwater quality.

- Assessment of the potential cumulative groundwater impacts with the adjacent Carmichael Coal Mine Project. The location of the proposed Carmichael Mine site is shown in Figure 12-1.
- Developing a groundwater monitoring plan.

The modelling used conservative parameters and values and is considered to represent the worst case scenario for potential groundwater impacts resulting from the project.

An assessment of the potential presence of stygofauna in the groundwater within the project site was also undertaken. The stygofauna assessment is included in the *Aquatic Ecology and Stygofauna Report* (Appendix G). A summary of the findings of the stygofauna assessment is included in Section 12.4.10.

12.3 GROUNDWATER REGIME

The regional geology in the vicinity of the project site broadly comprises the following strata:

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

The typical stratigraphy of the project site is shown on Figure 12-2. Figure 12-3 shows the underlying solid geology. Figure 12-4 shows a cross-section illustrating the distribution of hydrogeological units across the region and within the project site.

The hydrogeology of each stratigraphic unit is described in the following sections.

12.3.1 Quaternary Sediments

Published regional geological mapping indicates the presence of fluvial sediments associated with present day drainage features. 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 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.

The absence of shallow groundwater on the project site is further evidenced by the documented history of difficulties in finding water for cattle in the grazing properties that make up the project site (*Non- Indigenous Cultural Heritage Report*, Appendix P). 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 Carmichael River alluvium is located in a separate catchment from the project site.

12.3.2 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 thick. The Tertiary sediments are thin or absent on the elevated ridge of Darkies Range (Figure 12-5).

In elevated areas, recharge is diffuse and limited to sporadic rainfall events over small catchment areas. As a result of the limited recharge, the localised Tertiary sediments along Darkies Range are dry and unsaturated. 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, and the diffuse rainfall catchment area increases.

A water table forms within these sediments in the south-east of the project site and extends east towards the Belyando River. The hydraulic gradient is also to the east, reflecting the regional topography and surface water catchment setting. Where present within the project site, the water table is generally deep (25 to 55 m below ground level) and entirely disconnected from local surface drainage features. Further east, the water table is typically 15 to 20 m below North Creek and 20 to 25 m below Tomahawk Creek. Groundwater from this unit is likely to discharge to the Belyando River.

Tertiary sediments are present within the Lake Buchanan drainage basin to the west of Darkies Range (Figure 12-5). These sediments are discontinuous with the Tertiary sediments east of Darkies Range. The Tertiary sediments underlying Lake Buchanan host a shallow water table that is a regional discharge point for groundwater from underlying units.

Due to the lack of a shallow groundwater resource associated with drainage features, local groundwater use is focussed within the Tertiary sediments. A total of 18 private bores target groundwater within the Tertiary sediments within 20 km of the project site (Figure 12-6). Private bores are typically 20 to 30 m deep and yield fresh to slightly brackish water suitable for use as cattle watering supply.

12.3.3 Clematis Sandstone

The Clematis Sandstone is a massive sandstone unit, with minor interbeds of siltstone and claystone. 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 resulting in a clay-bound, low to moderately permeable unit.

Due to the prominence of the outcropping relative to the surrounding area, the Clematis Sandstone is generally dry within the project site. Where present in this unit within the project site, the water table is at depths in excess of 100 m.

In the north of the project site, a normal fault is present in this unit and the underlying strata. To the east of the fault, a thin wedge of Clematis Sandstone has been downthrown by approximately 100 m and is now truncated against the Rewan Formation on the west of the fault. In this area, the deeper Clematis Sandstone lies below the water table. The saturated thickness of this unit reaches 50 m close to the fault and gradually reduces to the east as the base of the unit rises above the water table.

The generally dry nature of the Clematis Sandstone within the project site and the relatively deep localised water table within the vicinity of Darkies Range indicate a low rate of groundwater recharge in this area. Groundwater flow reflects surface topography and catchment boundaries, with limited discharge into overlying formations. Lake Buchanan is an inferred indirect discharge zone for the Clematis Sandstone groundwater via the Moolayember Formation. The salt pans that surround Lake Buchanan and the saline lake water quality indicate that volumes of groundwater discharging to the lake are low and readily removed by evaporation.

This unit is a recognised regional aquifer of the Great Artesian Basin (GAB) and is the most productive unit in the vicinity of the project site. However, as this unit is generally dry and unsaturated within the project site there are no private bores in the Clematis Sandstone within the project site. A total of eight private bores target groundwater within this unit within 20 km of the project site (Figure 12-6). These bores have moderate yields (up to 6 L/s) of fresh to slightly brackish water typically used as cattle watering supply.

12.3.4 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 (Figure 12-3). The subcropping unit is covered by Tertiary sediments.

Regionally, the Moolayember Formation forms a low permeability unit that confines the underlying Clematis Sandstone. Localised bands of more permeable sandy clay sediments have been recorded in the vicinity of the project site, although yields remain low (0.15 to 1.3 L/s).

This unit is recharged by runoff from Darkies Range, seepage from the overlying Tertiary sediments and discharge from the underlying Clematis Sandstone. Groundwater flow reflects surface topography and catchment boundaries, 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. As described above, Lake Buchanan is an inferred discharge zone for this unit and the underlying Clematis Sandstone.

A total of eight private bores target groundwater in this unit within 20 km of the project site (Figure 12-6). These bores have low yields variously recorded as ‘salty’ and slightly brackish but suitable for use as cattle watering supply. The elevated groundwater salinity is likely to reflect the high groundwater residence times arising from the low permeability of this unit.

12.3.5 Rewan Formation

The Rewan Formation is a thinly interbedded sequence of siltstone, claystone and minor fine grained sandstone. 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.

The Rewan Formation is a recognised regional aquitard and acts as a basal confining unit to the overlying Clematis Sandstone aquifer. This unit is characterised by low primary porosity and as a result, groundwater movement is controlled by local fracture sets. Where fractures are intersected this unit shows slightly higher permeability, and conversely, where limited fractures are intersected this unit shows lower permeability associated with the primary porosity. Bulk permeability of this unit is therefore constrained by the degree of connection between any localised fractures. 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.

Rainfall recharge to the Rewan Formation is very low due to limited diffuse rainfall infiltrating Darkies Range and the overlying Tertiary sediments. Runoff from the eastern slopes of Darkies Range may concentrate at the break of slope and act to locally enhance recharge into this unit. However, recharge is further limited by the low permeability of this unit. The generally very low rates of recharge are confirmed by the typically dry and unsaturated nature of these sediments along Darkies Range. Where present in this unit, the potentiometric groundwater surface is typically deep (i.e. 100 m below ground level).

Groundwater movement is a subdued reflection of the typography and surface water catchments. Limited discharge into overlying formations is the main discharge mechanism. However, discharge volumes are similarly very low due to the very low rates of groundwater recharge.

This unit is typically dry and unsaturated within the project site. In the vicinity of the project site, private bores within the Rewan Formation are also limited. A total of three private bores within 20 km of the project site may intersect localised fractures within the Rewan Formation containing groundwater (Figure 12-6). These private bores are 55 m to 100 m deep and are expected to yield low volumes of fresh to moderately saline water typically used as cattle watering supply.

12.3.6 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.

Groundwater storage and movement occurs within the cleats that intersect the coal seams. Other sediments in the coal overburden and interburden sequence exhibit very low permeability and form discrete confining units between the coal seams. The Betts Creek Beds may therefore be categorised into the following hydrogeological units:

- Hydraulically "tight" and hence very low yielding to essentially dry sandstone and siltstone that comprise the majority of the Betts Creek Beds inter-burden/overburden; and
- Low to moderately permeable coal seams which are the primary water bearing strata within the Betts Creek Beds.

Data shows that limited recharge occurs through the elevated topography of Darkies Range into the underlying Betts Creek Beds. However, this recharge is limited by the layered, low permeability interburden and overlying Rewan Formation that retard downward flow. Slightly more recharge is expected where the coal seams subcrop against the weathered Betts Creek Beds, although the clayey nature of this weathered material will also limit recharge. Ephemeral surface runoff from Darkies Range that collects in drainage lines and at the break of slope are also considered areas where recharge to the Betts Creek Beds could occur, although the recharge volumes will be limited by the small size of these recharge zones and the thickness of overlying Tertiary sediments. Overall, the Betts Creek Beds recharge rate will be low. The relatively deep water levels support this conclusion.

Groundwater movement 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 flow divide, with groundwater flowing west towards Lake Buchanan, and east to south-east following the surface water catchments generally towards the Belyando River.

Limited discharge into overlying formations is the main discharge mechanism. However, discharge volumes are similarly very low due to the very low rates of groundwater recharge.

Due to the significant depth of these sediments to the west of Darkies Range, private bores within this unit are located in the shallower deposits close to the subcrop line (Figure 12-3). A total of 13 private bores within 20 km of the project site target groundwater within the Betts Creek Beds (and underlying Joe Joe Group) (Figure 12-6). Private bores are between 4 m and 150 m deep with low yields (less than 4 L/s). These yields represent the bores that successfully intersected cleats and fractures and are considered representative of the more permeable profiles within this unit.

Groundwater quality is highly variable with depth and location. Bores screened within the coal seams yield slightly brackish to brackish groundwater, whilst bores screening the interburden yield fresh to slightly brackish groundwater. Groundwater is also slightly less saline at the break of slope from Darkies Range, where salinity is reduced by enhanced recharge. Groundwater is suitable for use as cattle watering supply.

12.3.7 Joe Joe Group

The Joe Joe Group comprises conglomerate, lithic sandstone, siltstone, minor mudstone and coal. This unit is the base unit of the Galilee Basin and underlies the Betts Creek Beds, which contain the target coal seams for the project (Figure 12-4). As this unit dips beneath the Betts Creek Beds and Darkies Range, it is located at significant depths (in excess of 450 m). The Joe Joe Group subcrops to the east of the project site beneath the Tertiary sediments, and therefore is not exposed at the surface in the project site.

The Joe Joe Group is not directly impacted by the project and lies beneath the target coal seams and low permeability Betts Creek Beds underburden. The low permeability of this underburden will retard groundwater interaction with the overlying units. Similar to the Betts Creek Beds, this unit is also expected to be deeply weathered beneath the Tertiary sediments. Recharge and discharge mechanisms are therefore expected to be equivalent to those of the overlying Betts Creek Beds.

Any indirect impacts to this formation will be manifest through the Tertiary sediments and the associated water table east of the mine. This formation is therefore not discussed further in this assessment.

12.4 GROUNDWATER ASSESSMENT

The project involves open cut and underground mining. The key potential impacts on the groundwater regime that could arise directly from the proposed mining operations include:

- Dewatering by extracting coal by longwall mining and open cut mining and in so doing, lowering surrounding groundwater levels;
- Subsurface subsidence cracking of strata overlying the proposed longwall mines, changing the permeability of the overlying units and influencing surrounding groundwater levels;
- Construction of a tailings storage facility (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.

12.4.1 Overview of Mining Activities

The proposed open cut mining area will extend over a 12 km strike length and reach a depth of approximately 300 m at its deepest point (Figure 12-7). Open cut mining will target the A and B seams over the full extent of the mining area, and the C seam in the northern open cut mining area. As the open cut mining area progresses west, following the dip of the target coal seams, it will intersect several geological units including the Betts Creek Beds, Rewan Formation and superficial Tertiary sediments (Figure 12-8). The open cut mining area will not intersect any areas of saturated Clematis Sandstone.

The project will also involve establishing up to three longwall operations in the Northern and Southern Undergrounds (Figure 12-7). The Northern Underground will involve dual longwalls targeting the D seam and the overlying A seam. In dual seam areas of the Northern Underground, the D seam will be extracted in advance of the overlying A seam. The layout of the Northern Underground is constrained by the project site boundary and the geological fault that has been identified through the northern part of the Northern Underground Mining Area.

The Southern Underground will involve a single longwall targeting the C seam. The Southern Underground partially underlies the open cut mining area. In this area, longwall panels within the C seam will be extracted in advance of open cut mining of the overlying seams.

When longwall mining takes place, subsurface cracking occurs in the strata overlying the area from which coal has been extracted (the goaf) (Figure 12-9). Subsidence generates cracking that 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 cracking. The height of cracking is important in assessing the impact of mining on the groundwater regime and groundwater inflow to the mine. The *Subsidence Report* (Appendix A) predicts that the height of connective cracking will be up to 120 m above the coal seam in single seam mining areas, and 180 m above the upper A seam in the dual seam mining areas of the Northern Underground.

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 upper 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 (Section C-C[1] Figure 12-8). The 180 m predicted height of connective cracking would therefore intersect the overlying Clematis Sandstone in these areas. Subsurface subsidence cracking from the Southern Underground will not intersect any areas of saturated Clematis Sandstone.

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 areas. 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. The zone of depressurisation is conservatively defined by a 1 m lowering of the potentiometric groundwater surface. A 1 m lowering of the potentiometric groundwater surface is typically adopted in defining the zone of depressurisation as this represents the reasonable limit of precision that can be inferred from groundwater modelling and is within the likely natural range of groundwater level fluctuations within any potentially impacted aquifers.

12.4.2 Overview of Modelling

Groundwater Model

A 3D numerical groundwater flow model was developed to predict the extents of depressurisation and the associated impacts on groundwater users and the surrounding environment. A detailed description of the groundwater model is provided in the *Groundwater Report* (Appendix I). The model represented the key geological units as 18 layers and extended 75 km north-south and 85 km east-west. The groundwater model was based on the project geological model as well as all published lithological logs within the model extents, including drilling logs from the adjoining Carmichael Coal Mine Project and the DNRM groundwater database. The groundwater model was calibrated to existing groundwater levels using reliable measurements from all representative local and regional bores located over an area of 6,375 km^2.

The 3D numerical model included changes to model parameters to simulate the effects of subsurface subsidence cracking. The inherent uncertainty associated with subsidence cracking height and associated permeability predictions was addressed by adopting conservative key modelling assumptions. The model represents the predicted continuously cracked zone above each longwall as highly permeable and where the zone of continuous cracking is predicted to intersect only part of an overlying geological unit, the entire thickness of that unit is conservatively represented with a high permeability. The modelled vertical conductivity adopted for the cracked areas of the Clematis Sandstone above the Northern Underground is so high as to be considered uniformly free-draining.

These assumptions more than adequately account for any uncertainty associated with subsidence cracking predictions, and therefore provide a conservative basis for assessing potential worst case groundwater impacts.

Sensitivity Analysis

The sensitivity of the model predictions to the input parameters was tested and analysed. The sensitivity 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 software; and

- A wide, highly permeable fault plane with the same hydraulic properties 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 permeability.

It was also observed that changing the recharge and hydraulic conductivity parameters increased the overall model error. This indicates that the magnitude of these sensitivity 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. Fault permeability 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 to changes in model parameters is acceptable and the model is not likely to have underpredicted any significant impacts.

Model Predictions

Operations Phase

The effects of the proposed mining operations on the groundwater regime can be divided into two distinct areas:

- The Northern Underground where dual seam underground mining is proposed below the elevated ridgeline of Darkies Range, and subsidence cracking will potentially result in hydraulic connection between the underground mines and the overlying Clematis Sandstone; and
- The lower lying area in the south of the project site where the open cut mining area and single seam Southern Underground are proposed, and the Clematis Sandstone is essentially absent.

In the Northern Underground Mining Area, groundwater levels are predicted to be affected by longwall mining in the A and D coal seams. Longwall mining will depressurise the coal seams and overlying and underlying strata. Depressurisation will propagate through the Betts Creek Beds, Rewan Formation and Clematis Sandstone (where saturated), and will be enhanced by the increased hydraulic conductivity of strata subject to connective subsidence cracking (Section C-C[1] Figure 12-8).

The Clematis Sandstone is predicted to be depressurised most significantly where it is saturated on the eastern side of the fault (Figure 12-10). The saturated thickness of the Clematis Sandstone prior to mining in this area is approximately 50 m. The modelling predicts that the potentiometric surface may be lowered by up to 33 m in response to mining. Beyond the extents of mining subsidence, the depressurisation effects within the Clematis Sandstone rapidly diminish 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 extents of depressurisation within the coal seams and broader Betts Creek Beds in the north of the project site are localised to a radius of approximately 2 km from the proposed underground mine workings. In general, the lateral extent of depressurisation is constrained in the Northern Underground area by the largely dry and unsaturated nature of the elevated, outcropping units in this area.

Depressurisation in the remainder of the project site differs from the Northern Underground Mining Area, because the Clematis Sandstone is typically absent, except in the south-west of the project site where this stratigraphic unit is dry and unsaturated. Groundwater within the Clematis Sandstone will not be intersected by either the open cut mine, or by connective subsidence cracking above the Southern Underground. The Clematis Sandstone may therefore only be impacted indirectly by mining reducing pressures in the Rewan Formation as it is exposed in the open cut mine, or cracked above the underground mine (Section A-A[1] Figure 12-8). This results in a limited zone of depressurisation during the operations phase extending 2 km from the project site as shown in Figure 12-10. Groundwater levels may be lowered by up to 2 m in a localised zone south-west of the Southern Underground.

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 water table within the Tertiary sediments will be affected by depressurisation, resulting in drawdown of the groundwater level within a radius of up to 5.5 km from the open cut mining area (Figure 12-10). Water levels in the Moolayember Formation are not predicted to be significantly affected by the project.

Groundwater inflow to the mining operations will occur from the coal seams where exposed in the open cut and underground mining areas, and from overlying strata where connective cracking is predicted to occur above mined longwall panels.

Numerical modelling predicts that inflow volumes to the open cut mining area will gradually increase up to 12 ML/day during the early years of mining. The modelled inflows then decline to less than 4 ML/day following commencement of mining in the Southern Underground.

Modelled inflow rates to the Northern Underground vary from 1 to 2 ML/day over the first 30 years of the project. Following completion of the D seam underground mine, inflow rates into the overlying A seam underground mine are predicted to increase up to 4 ML/day. This increase is due to the height of connective cracking in dual seam mining areas and intersecting and draining water from the overlying Clematis Sandstone where it is saturated above the mine. Overall, groundwater inflow rates to the underground mining areas are lower than those predicted at the open cut mine. Groundwater inflows to the mining areas will be managed as part of the proposed mine water management system described in Section 13 – Surface Water.

Post Closure

Predictive modelling was undertaken to simulate 200 years of groundwater recovery post mining. This simulation removes all drain cells used to simulate dewatering from the coal seams during mining operations, 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 process will reduce the hydraulic gradient and magnitude of drawdown immediately surrounding the mined areas, but also allow the zone of depressurisation to expand as water from the surrounding groundwater systems flow into the mines (Figure 12-10).

It is important to note that the groundwater model allows perfect hydraulic interconnection between the geological units 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 extent of depressurisation post mining. 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 extent and level of depressurisation increases.

12.4.3 Impact on the Great Artesian Basin

The Clematis Sandstone which occurs on the project site is an aquifer regulated under the *Water Resources (Great Artesian Basin) Plan 2006* (GAB WRP). The Moolayember Formation and Ronlow Beds, both located west of the project site, are also named aquifers under the GAB WRP.

Modelling predictions indicate that the project will locally depressurise the Clematis Sandstone where it is saturated within and adjacent the project site (Figure 12-10). This depressurisation will result in some water from these GAB aquifers 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. No significant short-term or long-term loss of recharge to the GAB is predicted as a result of the project.

The groundwater model has been used to estimate the 'water take' from the GAB aquifers due to the depressurisation induced by mining. Water take will gradually increase 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 water take will peak at 9 ML/day when subsurface subsidence cracking from the A seam longwall first interconnects the Northern Underground with the saturated Clematis Sandstone on the downthrown side of the fault. For the purposes of modelling worst-case water take from the GAB, the groundwater assessment has conservatively assumed that the permeability of the cracked strata overlying the mine is effectively ‘free-draining’.

The predicted water take is limited to the Clematis Sandstone and Moolayember Formation. These units are collectively designated GAB Management Unit 3 under the GAB WRP. No net take from the distant Ronlow Beds are predicted.

The volume of the ‘water take’ reduces post mining due to the reduced hydraulic gradients present around the open cut and underground mining areas. The long-term take from GAB Management Unit 3 is below 0.5 ML/day. Post mining water take from the Ronlow Beds is less than 0.015 ML/day. This modelled take occurs indirectly as a very slight reduction in flow from the Moolayember Formation to the Ronlow Beds and is considered negligible. The predicted peak water take during the operations phase of up to 9 ML/day is relatively inconsequential when compared to the estimated 65,000,000 GL estimated to be stored within the GAB.

Outside of the GAB aquifers there is also 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 Greater Western Sub-Artesian Area declared under the Queensland *Water Regulation 2002* (Water Regulation). Groundwater take from these formations will initially range from 2 to 16 ML/day during open cut and underground operations, and reduce to less than 5 ML/day following completion of open cut mining. Based upon modelled groundwater inflows to the final void, water take from the Greater Western Sub-Artesian Area is predicted to decrease post mining and reach an equilibrium of approximately 0.5 ML/day.

12.4.4 Impact on Surface Water Features

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 (Figure 12-10).

The lake is underlain by Tertiary sediments and the deeper Moolayember Formation. As discussed in Section 12.3.4, the Moolayember Formation subcrops at least 1 km west of the project site and therefore is not directly impacted by proposed mining activities.

Depressurisation of the Tertiary sediments and Moolayember Formation could theoretically occur indirectly, through propagation of depressurisation impacts from the Betts Creek Beds, Rewan Formation and Clematis Sandstone. However, modelling indicates that the maximum predicted zone of depressurisation remains a minimum of 6 km from Lake Buchanan and lake levels are unlikely to be impacted by the project.

12.4.5 Impact on Drainage Features

No watercourses as defined under the *Water Act 2000* (Water Act) are located on the project site.

As discussed in Section 12.3, there is a general absence of shallow groundwater in the vicinity of the project site. This is because the project site is located in the headwaters of the catchment where the topography is elevated and recharge is relatively low. The surface drainages have only short duration highly ephemeral flows following rainfall.

On the elevated ridgeline of Darkies Range the water table is typically located at significant depths of up to 100 m below ground level. In the lower lying areas beyond Darkies Range groundwater levels are typically at least 25 m below ground level.

Within the predicted extents of drawdown (Figure 12-10), the water table is at least 15 m, and more typically at least 20 m, below the base of any drainage feature and there is no direct groundwater – surface water interconnection in this area. The significant separating depth means that groundwater does not provide baseflow to drainage features in the vicinity of the project site, and therefore drawdown on the water table will not impact the overlying drainage features.

12.4.6 Impact on Springs

The closest springs to the project site are the Doongmabulla Spring Complex, 22 km to the south of the proposed mining area (Figure 12-10). The Doongmabulla Spring Complex is registered under the GAB Resource Operations Plan as the closest spring that could support significant cultural and environmental values.

The Clematis Sandstone is the source aquifer for the springs. As discussed in Section 12.3.3, the project site is located at the eastern margins of the Clematis Sandstone where this unit is largely dry and unsaturated. In the south of the project site, closest to the Doongmabulla Spring Complex, the Clematis Sandstone is generally absent (Figure 12-3). In this area, open cut mining and subsurface subsidence cracking above the Southern Underground Mine will only intersect a minor area of thin and unsaturated Clematis Sandstone (Figure 12-8).

The only mechanism by which the project could potentially impact on the springs would be via depressurisation of the underlying low permeability Betts Creek Beds and Rewan Formation in the south of the project site propagating upwards to the Clematis Sandstone and laterally 22 km to the springs.

The maximum predicted extent of depressurisation in the Clematis Sandstone extends to 2 km from the south-west of the project site during operations and 11 km post mining (Figure 12-10). This means that no significant depressurisation of the Clematis Sandstone due to the project will occur within 11 km from the Doongmabulla Spring Complex during or post mining and therefore no impacts on the springs are predicted.

12.4.7 Impacts on Groundwater Dependent Ecosystems

Due to the absence of shallow groundwater there are no Groundwater Dependent Ecosystems (GDEs) within or in proximity to the project site. The assessment of GDEs is discussed in Section 9 – Terrestrial Ecology.

12.4.8 Impact on Existing Groundwater Users

A bore census was carried out to identify private bores surrounding the project site that could potentially be impacted by the project. It included consultation with landowners, a search of the DNRM database, review of the EISs undertaken for the nearby Carmichael Coal Mine site, and an inspection of bores.

The bore census was targeted towards bores that could potentially be impacted by the project. The extent and nature of the water-bearing strata were also taken into account in planning the bore census. For example, areas to the east of the Betts Creek Beds subcrop are of limited concern due to the low potential for significant depressurisation through the base of the Betts Creek Beds into the underlying strata. A conservative search radius of 20 km beyond the project site boundary was undertaken in areas that could potentially be impacted by the project.

A total of 52 private bores were identified during the bore census (Figure 12-6). 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 12.4.2, post mining groundwater impacts 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 private bores. Of these, five are owned by Adani Mining Pty Ltd.

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 12.5.

Three of the bores predicted to be impacted post mining are also predicted to be impacted by the Carmichael Coal Mine Project. Cumulative impacts on groundwater users are discussed in Section 12.4.10.

12.4.9 Impact on Groundwater Quality

Key potential sources of groundwater contamination are seepage from:

- The TSF;
- The PSWSF;
- Overburden emplacement areas and the final void lake; and
- Hydrocarbon and chemical storage.

The TSF, PSWSF and overburden emplacement areas are discussed in detail below. Hydrocarbon and chemical storage will be managed in accordance with the measures described in Section 22 – Hazard and Risk. These measures are standard practice at mine sites and are designed to prevent the contamination of groundwater.

Wet tailings material will be stored in an out-of-pit TSF, which will be developed progressively over the life of the project. Dry power station waste will be stored in an out-of-pit PSWSF for the initial 10 years of operations, and thereafter stored within the overburden emplacement. The operation of the TSF and PSWSF are described in Section 7 – Tailings and Power Station Waste Storage Facilities. Overburden will initially be placed out-of-pit to the east of the open cut mining area. Once the open cut pits have been developed, overburden will be stored in-pit.

Key considerations in determining potential groundwater impacts associated with the TSF, PSWSF and overburden emplacement areas include whether they will give rise to significant seepage, the chemical properties of any seepage, and the characteristics of the underlying groundwater. The *Mine Waste Storage Facility Conceptual Design Report* (Appendix C) describes the results of geotechnical testing of the TSF and PSWSF foundation, as well as the tailings and power station waste properties. The *Geochemistry Report* (Appendix D) describes the results of geochemical testing of tailings, power station waste and overburden materials. Further detail on these studies as relevant to assessing groundwater quality impacts, is provided below.

Tailings Storage Facility

The TSF will be constructed to the east of the open cut mine. The TSF footprint is underlain by Tertiary sediments. Drilling within the footprint confirmed that shallow sediments are dry to depths in excess of 25 m. The deeper Tertiary sediments in the TSF footprint may be locally saturated at their base. Water quality within the Tertiary sediments is typically characterised as pH neutral to slightly alkaline with a salinity of 500 to 1,000 µS/cm.

Geochemical testing indicates that tailings are likely to generate pH neutral to slightly alkaline leachate with low salinity in the order of` 280 µS/cm. The concentration of soluble metals and major ions in TSF seepage is predicted to be generally very low. This indicates that the any leachate from the TSF is likely to be of similar quality to the existing groundwater. In the unlikely event of seepage from the TSF reaching the groundwater, degradation of groundwater quality is unlikely. There is only one private bore in proximity to the TSF (RN36400) and this bore will be removed during construction of the TSF.

Overall, the water table at the site of the proposed TSF is relatively deep, and any leachate generated from the facility will be of a similar quality to any groundwater that may be present in the underlying Tertiary sediments. The TSF 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 from TSF seepage are low.

Power Station Waste Storage Facility

The PSWSF will be constructed to the east of the open cut mine adjacent to the TSF. The underlying geology and groundwater setting are the same as described above for the TSF.

Geochemical testing of the power station waste shows that this material is likely to generate leachate with neutral pH, low to moderate salinity (in the order of 900 µS/cm) and low concentrations of soluble metals and major ions following exposure.

As with the TSF, leachate generated from the PSWSF will of a similar quality to any groundwater present at depth within the underlying Tertiary sediments. The PSWSF 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 PSWSF, hence risks to groundwater users are considered unlikely.

Overburden Emplacement Areas and Final Void Lake

The open cut mining area will be actively dewatered during mining operations. Mine dewatering will create a hydraulic groundwater gradient and induce groundwater flow towards the dewatered pit. Any water leaching through the overburden emplacements and into the underlying geology will therefore migrate towards the dewatered mining area. Section 13 – Surface Water describes the management of mine water during the project operations phase.

Post mining water levels within the final void are predicted to recover to a quasi-equilibrium level of approximately 255 m AHD. This level is below the pre-mining groundwater levels and means the final void will also act as a sink to groundwater flow. Water leaching through the overburden emplacements will therefore migrate into the lake formed within the final void. Geochemical testing concluded that overburden materials are likely to generate slightly alkaline, low salinity leachate with an Electrical Conductivity of approximately 350 µS/cm and low concentrations of soluble metals and major ions. This leachate is therefore unlikely to present any significant environmental risks to surrounding water quality.

Water will evaporate from the void 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. As a result, groundwater quality is highly unlikely to be impacted post closure.

12.4.10 Impacts on Stygofauna

Stygofauna are aquatic animals (generally invertebrates such as crustaceans) that live in groundwater. Stygofauna are known from limestone, calcrete, and fractured rock aquifers, but are most abundant in alluvial aquifers (Hancock *et al*, 2005). Within alluvial aquifers, stygofauna are typically concentrated in the hyporheic zone where surface waters and groundwater mix.

A desktop review of regional and local groundwater studies, stygofauna studies and other relevant technical reports was undertaken to determine the potential presence of stygofauna in the project area. This included publicly available reports prepared in relation to the Carmichael Coal Mine Project (GHD, 2012) and site-specific groundwater data from the groundwater field investigation for the project.

The desktop review confirmed that there is limited potential for significant stygofauna habitat or assemblages to occur within the project site for the following reasons:

- No alluvial, limestone, or calcrete aquifers are present in the vicinity of the project site. The nearest alluvial aquifer is associated with the Belyando River, approximately 40 km east of the project site and beyond the predicted extents of project impacts on groundwater;
- Groundwater within the project site is disconnected from ephemeral surface water drainage lines and there is negligible potential for hyporheic mixing zones that typically host stygofauna; and

- Groundwater within the project site is generally located at significant depths within underlying rock and this depth is not conducive to the presence of stygofauna.

A field investigation was undertaken to confirm the findings of the desktop review. The field investigation was undertaken in accordance with the Western Australia Environmental Protection Agency (EPA) guidelines for assessing stygofauna, *Guidance for the Assessment of Environmental Factors – Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia No. 54a* (Western Australia EPA, 2007) which is currently viewed as the best practice for investigating and assessing stygofauna throughout Australia.

The site investigation involved collection of representative groundwater samples and water quality data from 15 monitoring bores within the project site. Samples were obtained from the Tertiary sediments and the Clematis Sandstone which represent the key water-bearing units at the project site. Additional samples were also collected from the Rewan Formation and the Betts Creek Beds. All samples were analysed for the presence of stygofauna in a specialist laboratory.

The field investigation results supported the findings of the desktop review. The majority of bores (13 of 15) returned no stygofauna or other invertebrate fauna. Two bores returned a total of three specimens from two broad faunal groups as follows:

- Springtails (Collembola) – two specimens from a single bore within the Betts Creek Beds; and
- Mites (Acarina) – one specimen within the Rewan Formation.

Springtails and mites are both surface dwelling fauna that are typically naturally found in surface waters and in decomposing leaf litter. These specimens are therefore likely to have been introduced into the monitoring bores via contamination with surface litter (Hose, 2014). These samples were collected at depths in excess of 80 m below ground level which (as discussed above) is typically inconsistent with stygofauna development, except in the presence of limestone caves and subterranean voids.

While mites can be obligate stygofauna, the taxonomy results together with the groundwater setting indicate that this specimen is most likely to represent a common surface species rather than an obligate groundwater species.

In summary, the project is unlikely to result in significant stygofauna impacts due to the nature of the existing groundwater setting, the localised effects of groundwater depressurisation, and the lack of any confirmed stygofauna assemblage within the vicinity of the project.

12.4.11 Cumulative Impacts

Groundwater Depressurisation

The method of superimposition has been used to assess the potential cumulative groundwater impacts of the project with the Carmichael Coal Mine Project. Depressurisation predictions for each stratum due to each project were overlaid on a single map to identify any areas of overlap of impacts. Potential cumulative impacts could occur within any overlapping zones. The magnitude of total cumulative depressurisation within any overlapping zones is equivalent to the sum of the overlapping depressurisation contours for each project. By comparing the maximum predicted extents of depressurisation for each mine, this approach also allows for the identification of the maximum predicted extent of cumulative depressurisation. This means that the magnitude of total cumulative depressurisation can be quantified over the maximum potential extent of cumulative depressurisation, and provides a conservative assessment of the potential worst-case cumulative impacts on groundwater users and environmental values.

Predictions relating to the Carmichael Coal Mine Project were sourced from the Carmichael Coal Mine and Rail Project EIS Hydrogeology Report (GHD, 2012) and Supplementary EIS Mine Hydrogeology Report Addendum (GHD, 2013). The 1 m drawdown contour has been taken as the limit of impact for each project.

The results of the cumulative assessment, including figures showing predicted cumulative change in groundwater elevation and potentiometric groundwater surface, are provided in the *Groundwater Report* (Appendix I). The extent of cumulative depressurisation and the magnitude of project and total cumulative depressurisation is presented on these figures. These figures allow for the identification of the relative contributions to cumulative depressurisation of each project, the total cumulative depressurisation (i.e. the sum of the overlapping contours), and identification of groundwater users and environmental features within the limit of cumulative depressurisation.

Figure 12-11 shows the limited area within which potential cumulative groundwater depressurisation could potentially occur in all geological units. The cumulative depressurisation is most extensive in the coal seams that are targeted by both mining operations, with cumulative drawdown in the A seam, C seam and D seam by the end of mining.

The Carmichael Coal Mine Project does not propose to directly mine the Clematis Sandstone within the open cut mining areas, or fracture this unit above the underground mines. The Carmichael Coal Mine Project groundwater model therefore predicts no significant depressurisation of the Clematis Sandstone during or post mining. There is therefore no cumulative impact on the Clematis Sandstone.

During mining there is no cumulative drawdown on the water table within the Tertiary sediments. Post mining, the project may increase the drawdown predicted for Carmichael Coal Mine Project by up to 20 m. It should be noted that with respect to the Quaternary sediments, cumulative impacts are not predicted due to the separate catchment settings of these projects and the absence of these deposits in the vicinity of the project site.

Cumulative Impacts on Groundwater Users

The zone of potential cumulative depressurisation is concentrated largely in the area where the two projects adjoin. Groundwater use is very limited in this area, with only three bores (RN103875, RN132938 and Allens Bore) potentially experiencing a cumulative impact (Figure 12-11). These bores are located in the Betts Creek Beds and the Tertiary sediments. Figure 12-11 also shows the cumulative depressurisation within each of these formations.

RN103875 is located within the project site and will be effectively dealt with by the land access agreement for the mining lease application.

RN132938 is located within the Carmichael Coal Mine Project site and will be impacted by the Carmichael Coal Mine Project. This bore is owned by the proponent for the Carmichael Coal Mine Project.

Allens Bore is also predicted to be impacted by the Carmichael Coal Mine Project and is therefore likely to be subject to a make good agreement with the proponent for the Carmichael Coal Mine Project.

Cumulative Impacts on Other Features

The area of potential cumulative groundwater depressurisation does not include any other features that would potentially be impacted by groundwater depressurisation.

12.5 MONITORING

12.5.1 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 12-12). 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.

12.5.2 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 Section 24 – Environmental Management (Attachment 24-4).

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 Section 24 – Environmental Management (Attachment 24-4). 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 Section 24 – Environmental Management (Attachment 24-4). 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 12.6.

12.6 GROUNDWATER LICENSING AND REPORTING

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 12.4, 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 Water Regulation.

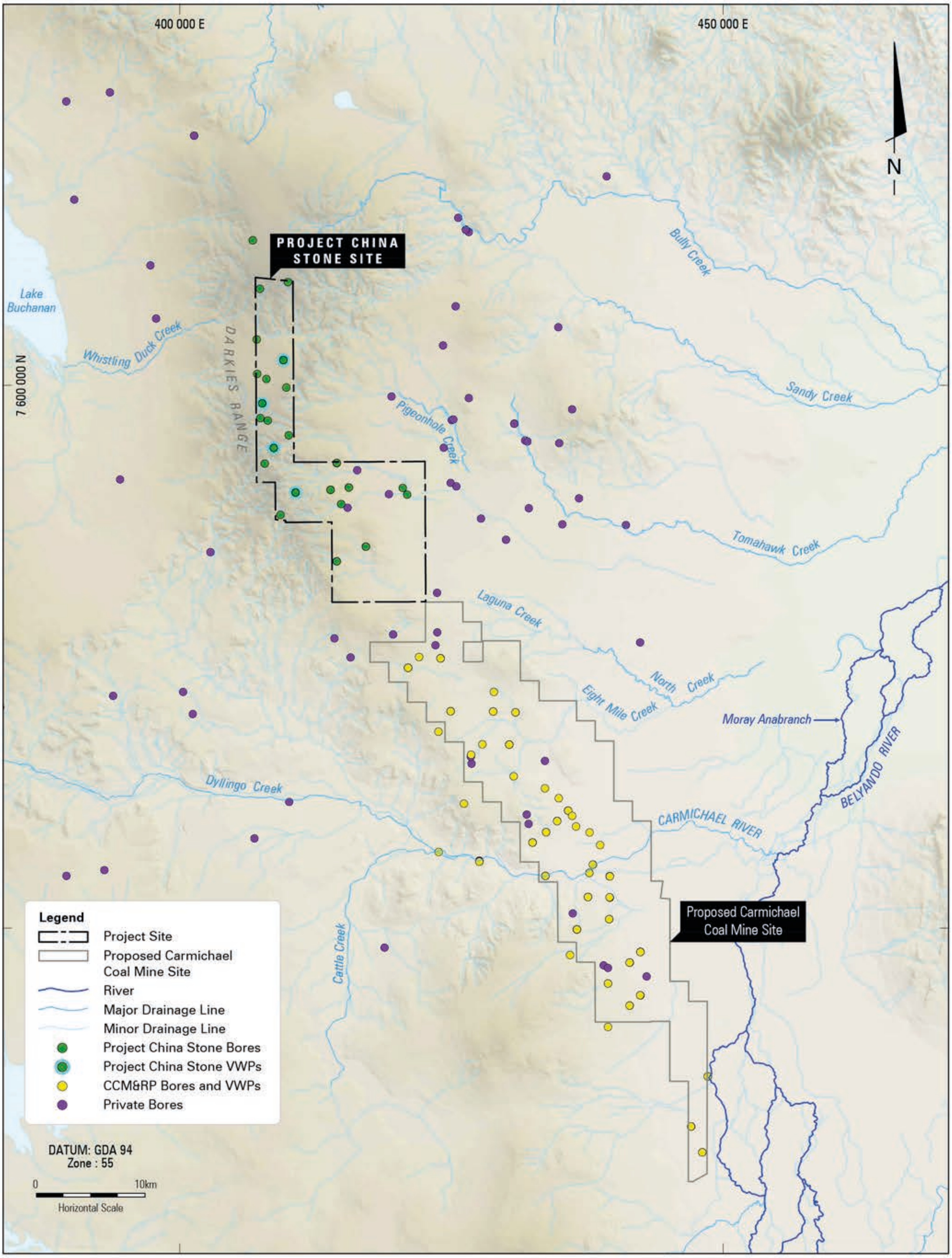
The administering authority for the Water Act is the DNRM. The proponent will be required to comply with the requirements and conditions of the water licence. The licence will specify the approved location and the source aquifer for groundwater take, along with an approved volumetric groundwater allocation. 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.

FIGURES



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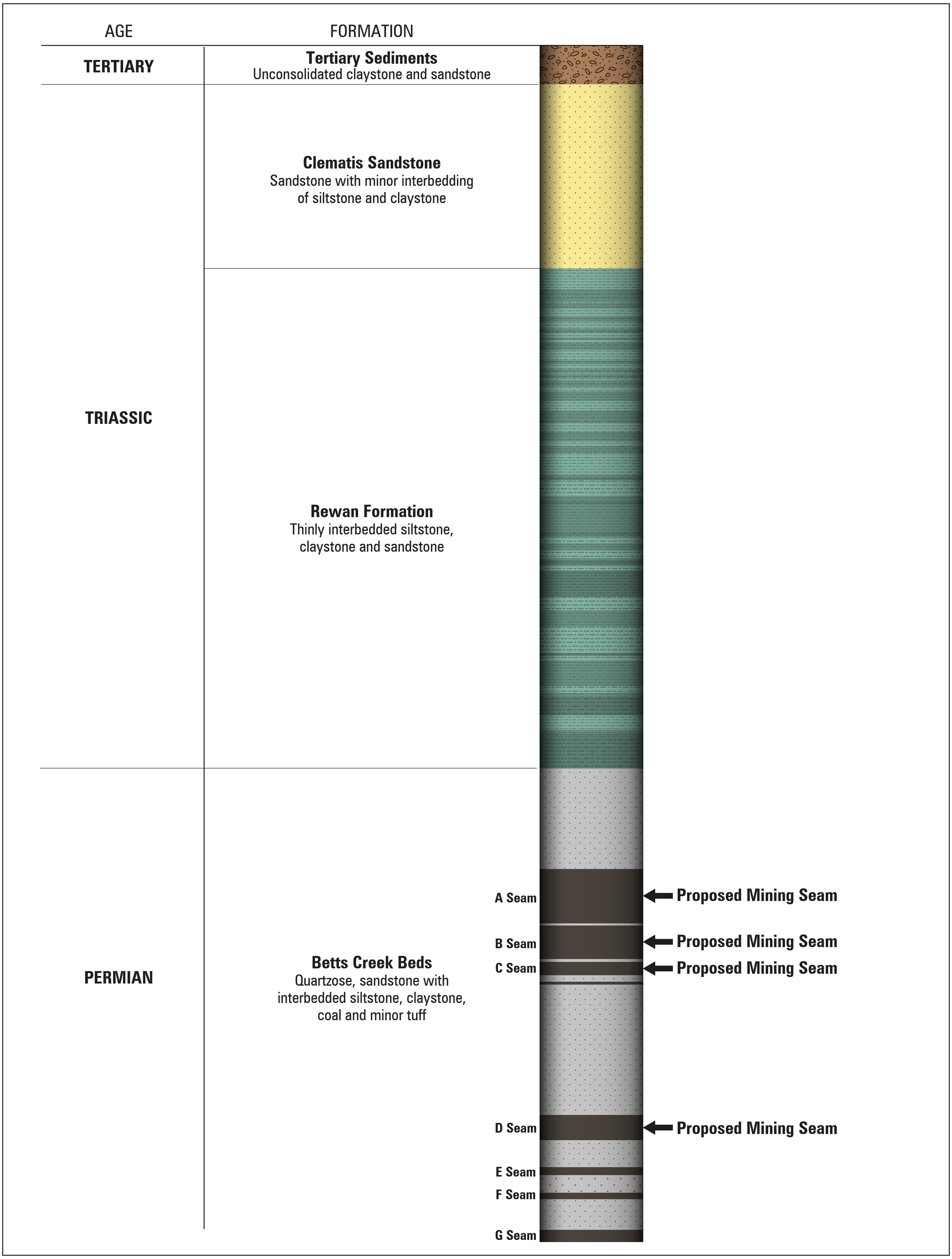
Groundwater Monitoring Bores

FIGURE 12-1



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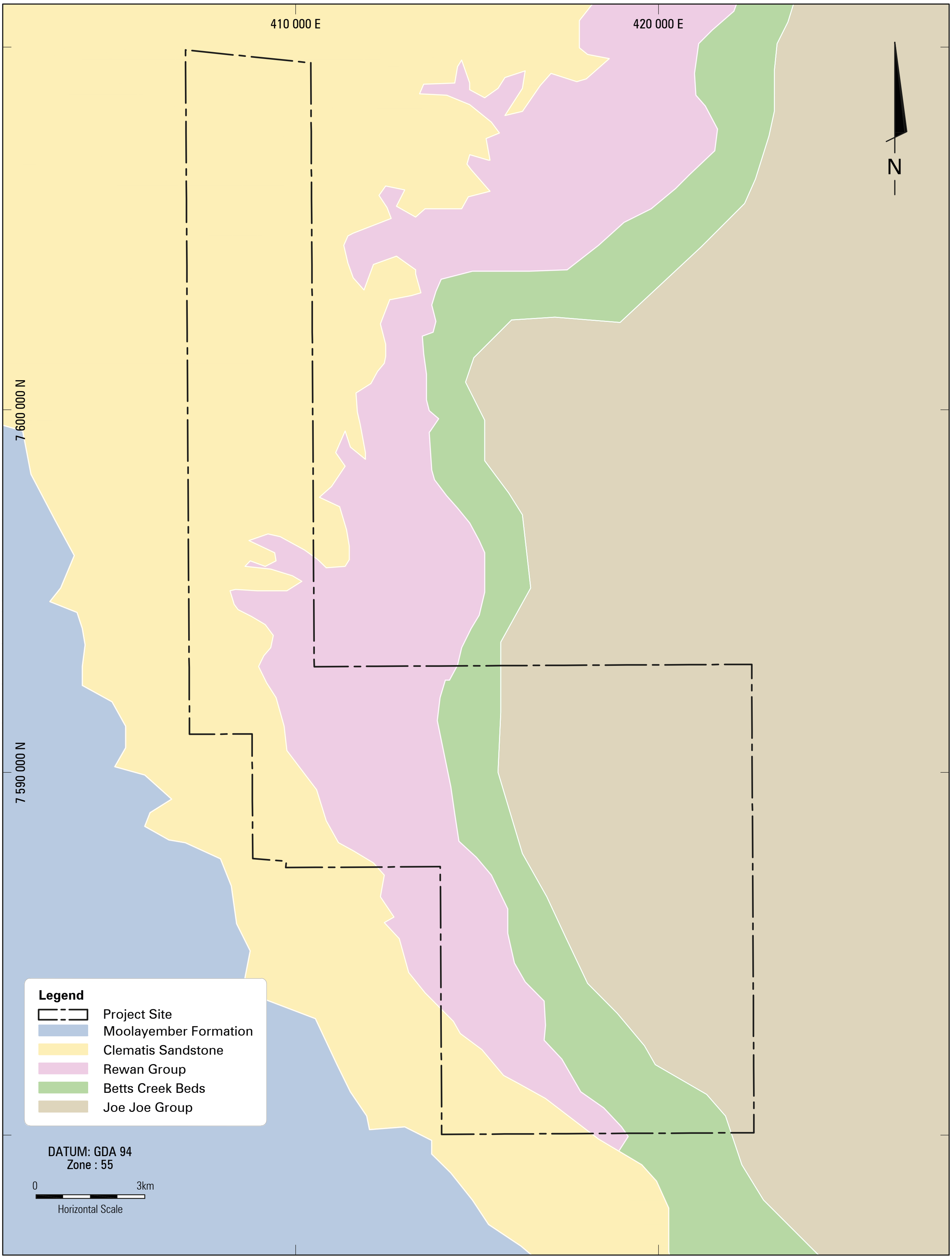
Project Site Typical Stratigraphy

FIGURE 12-2



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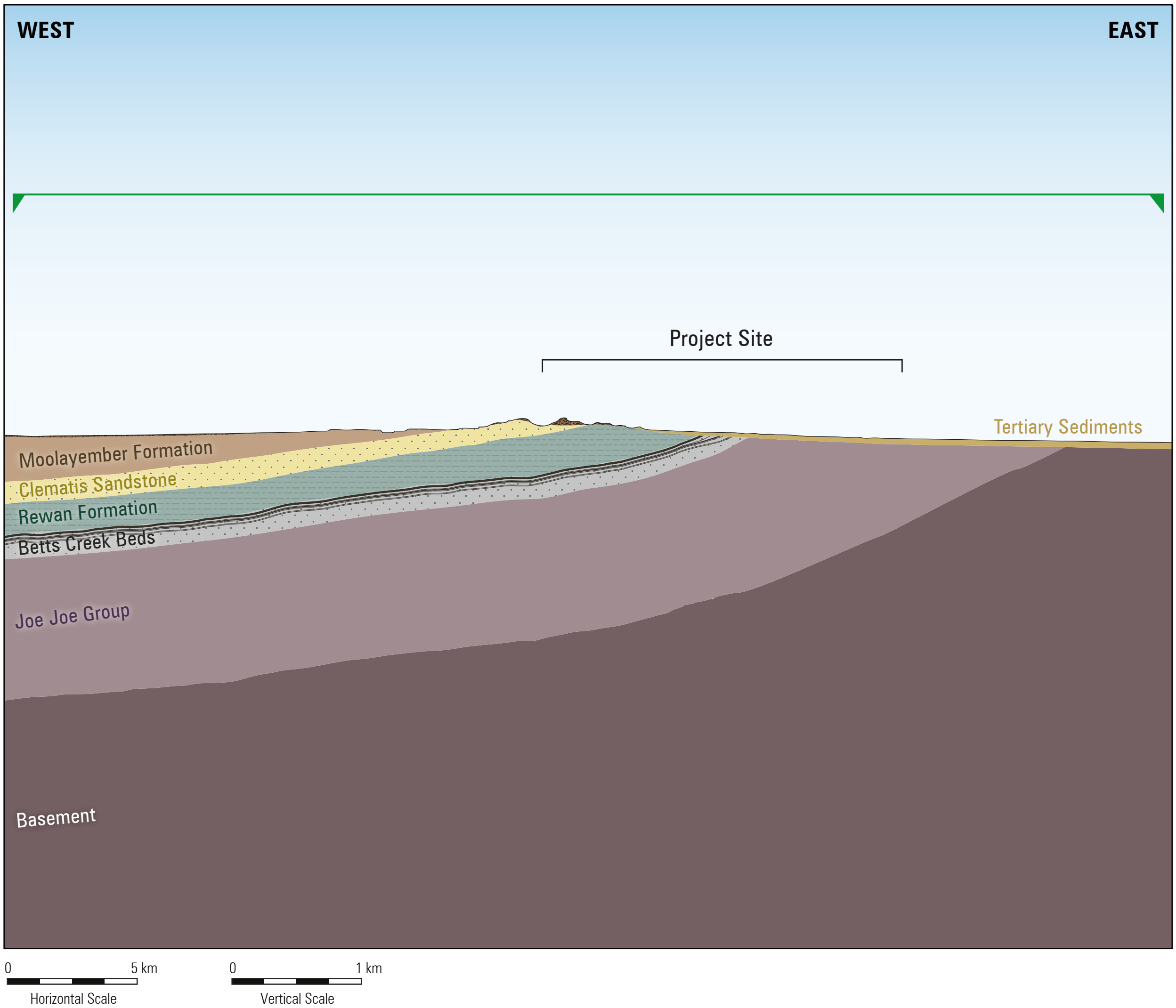
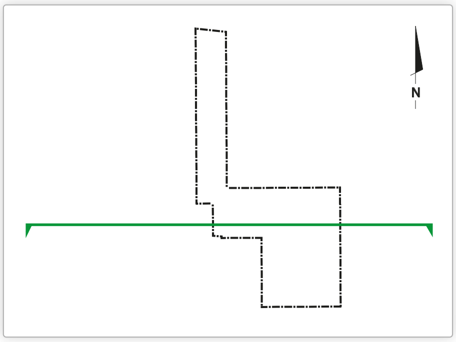
Solid Geology

FIGURE 12-3



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



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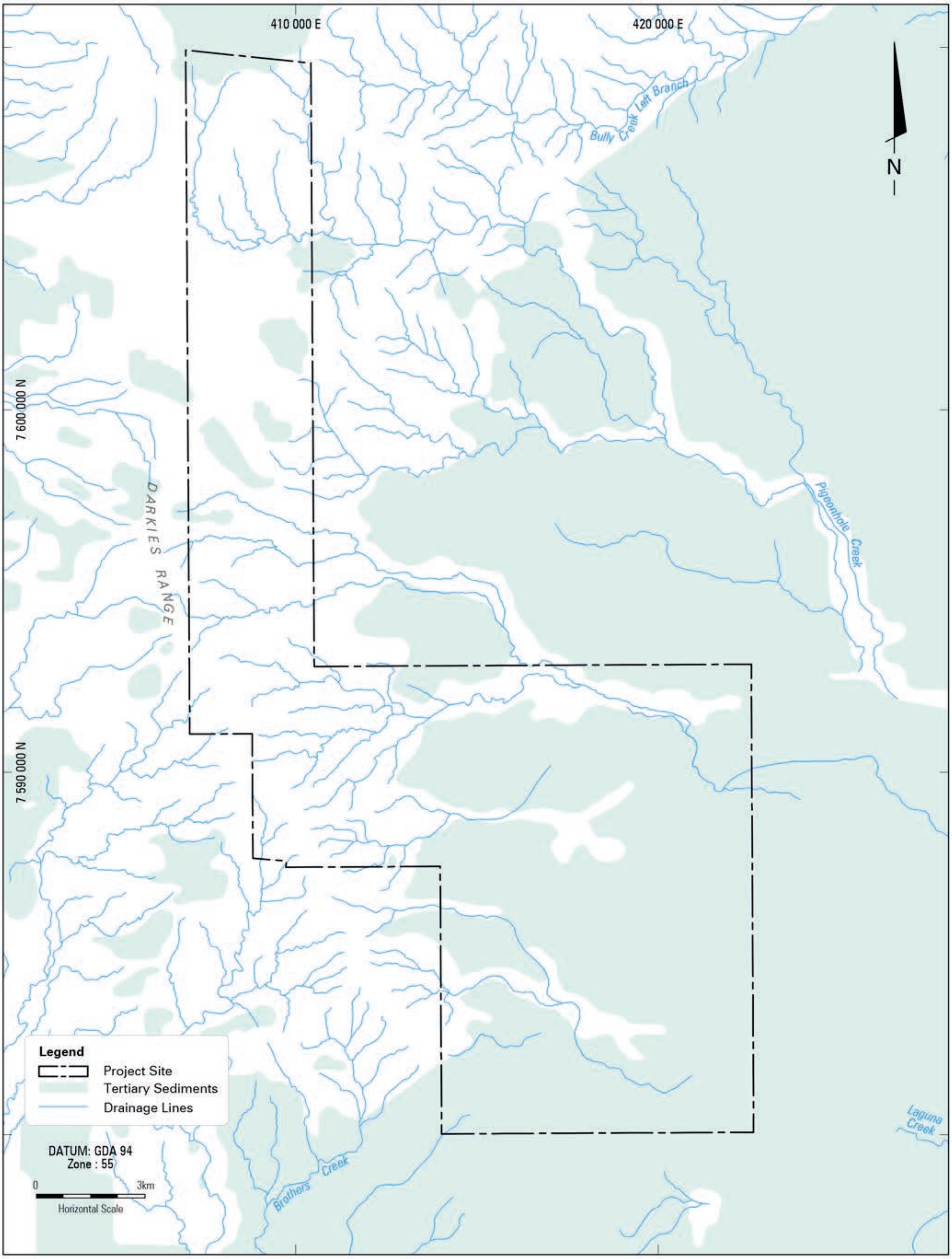
Regional Hydrogeology Cross Section

FIGURE 12-4



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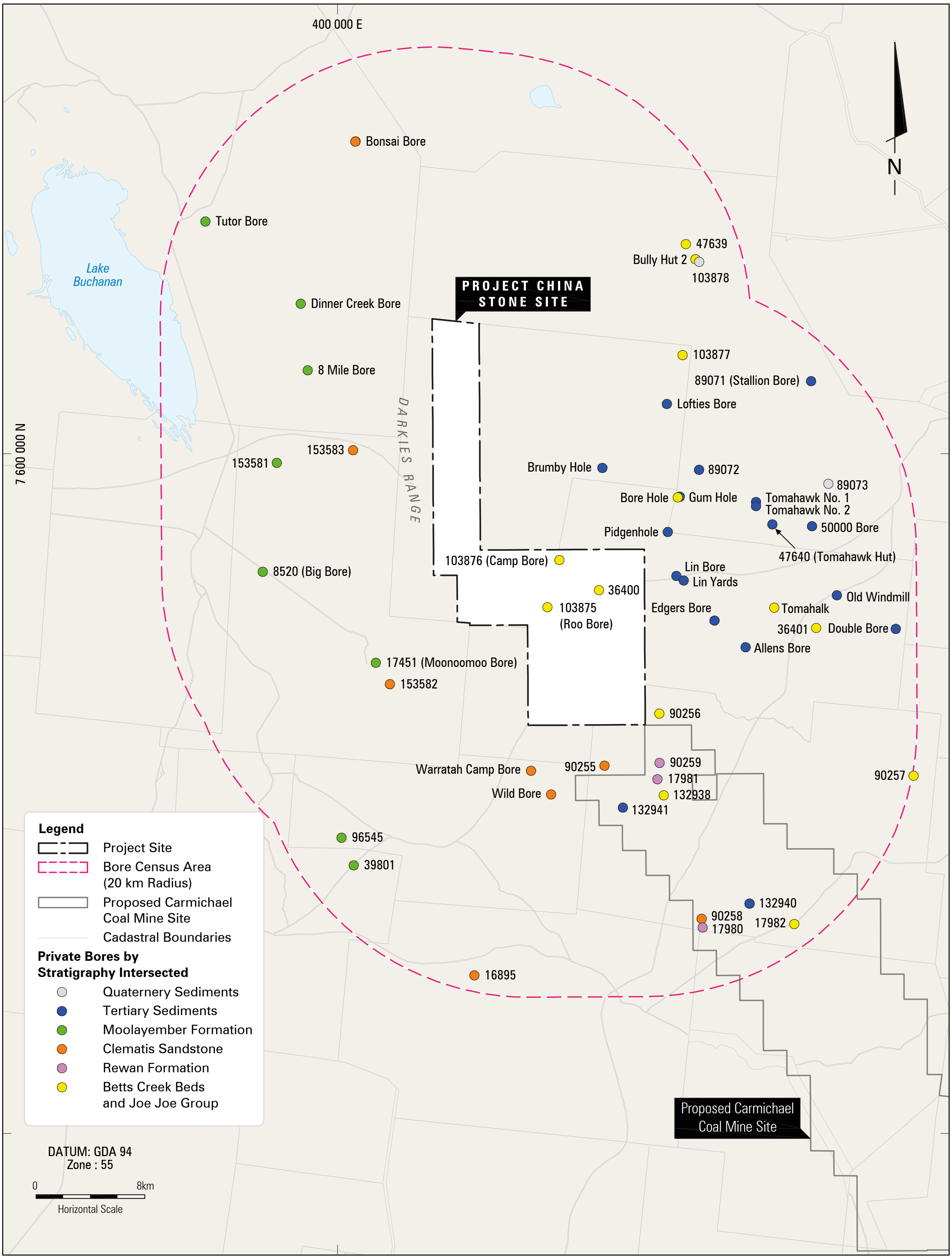
Distribution of Tertiary Sediments

FIGURE 12-5



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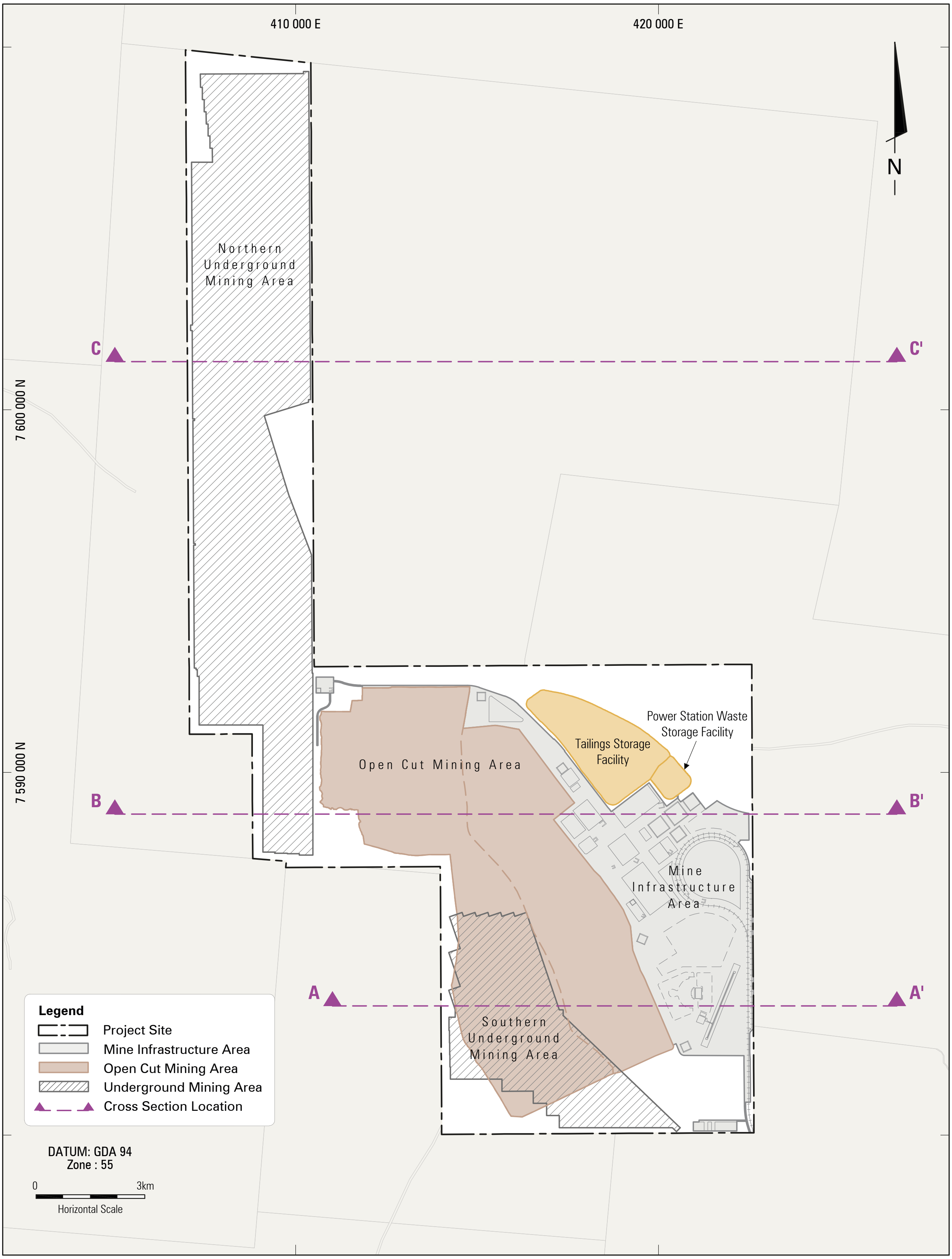
Groundwater Users

FIGURE 12-6



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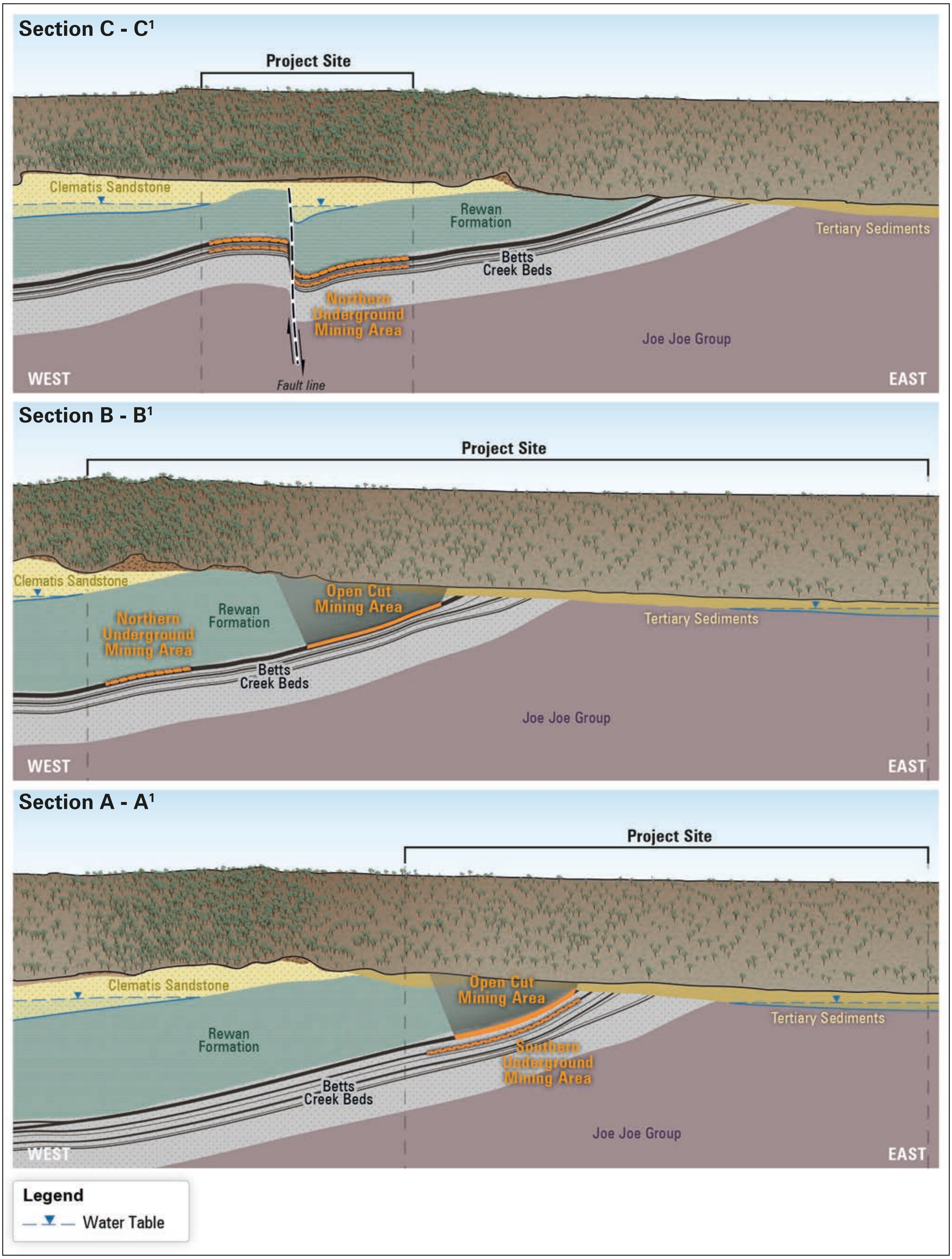
Project Layout

FIGURE 12-7



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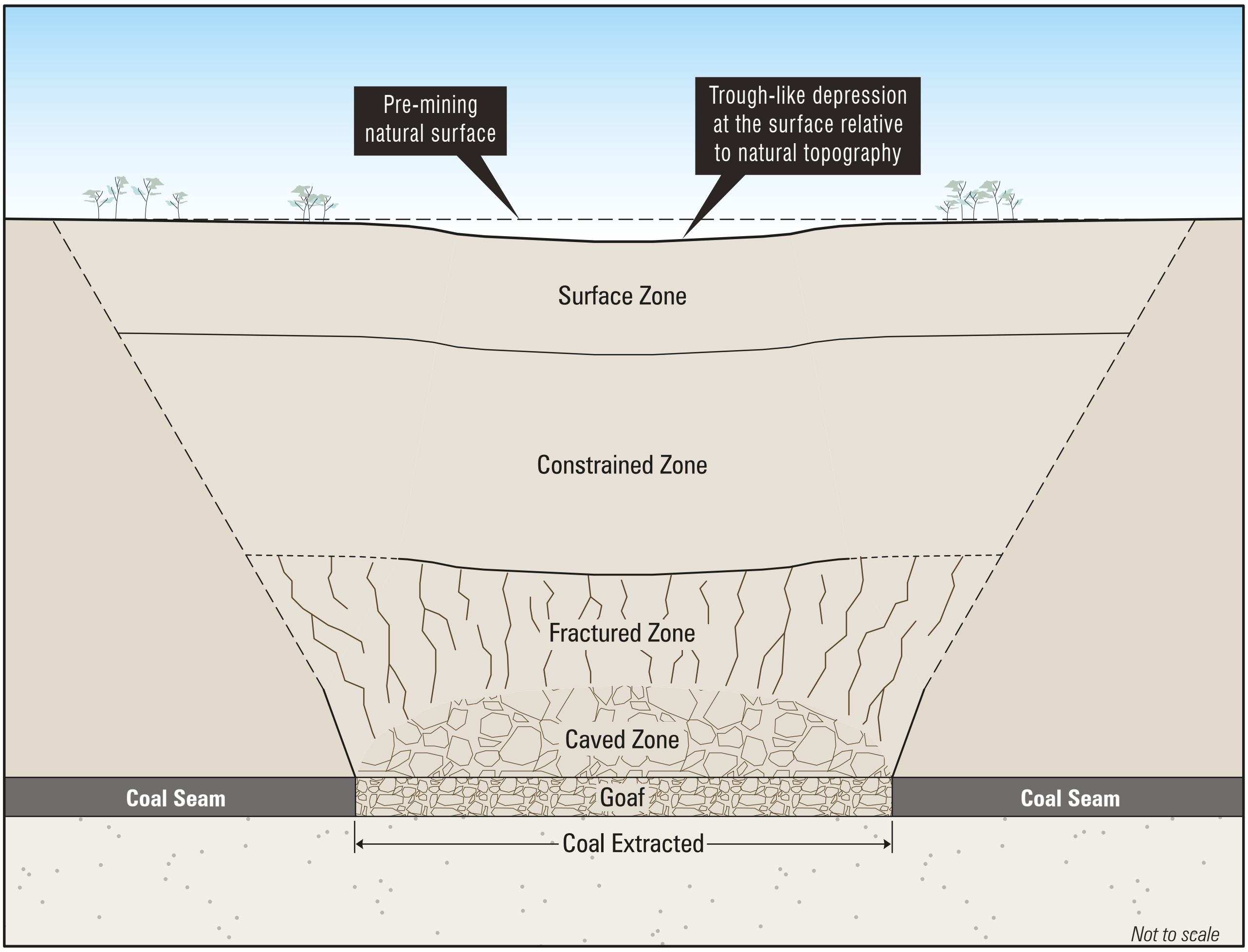
Hydrogeological Cross Sections of Project Site

FIGURE 12-8



Plan based on MSEC Figure

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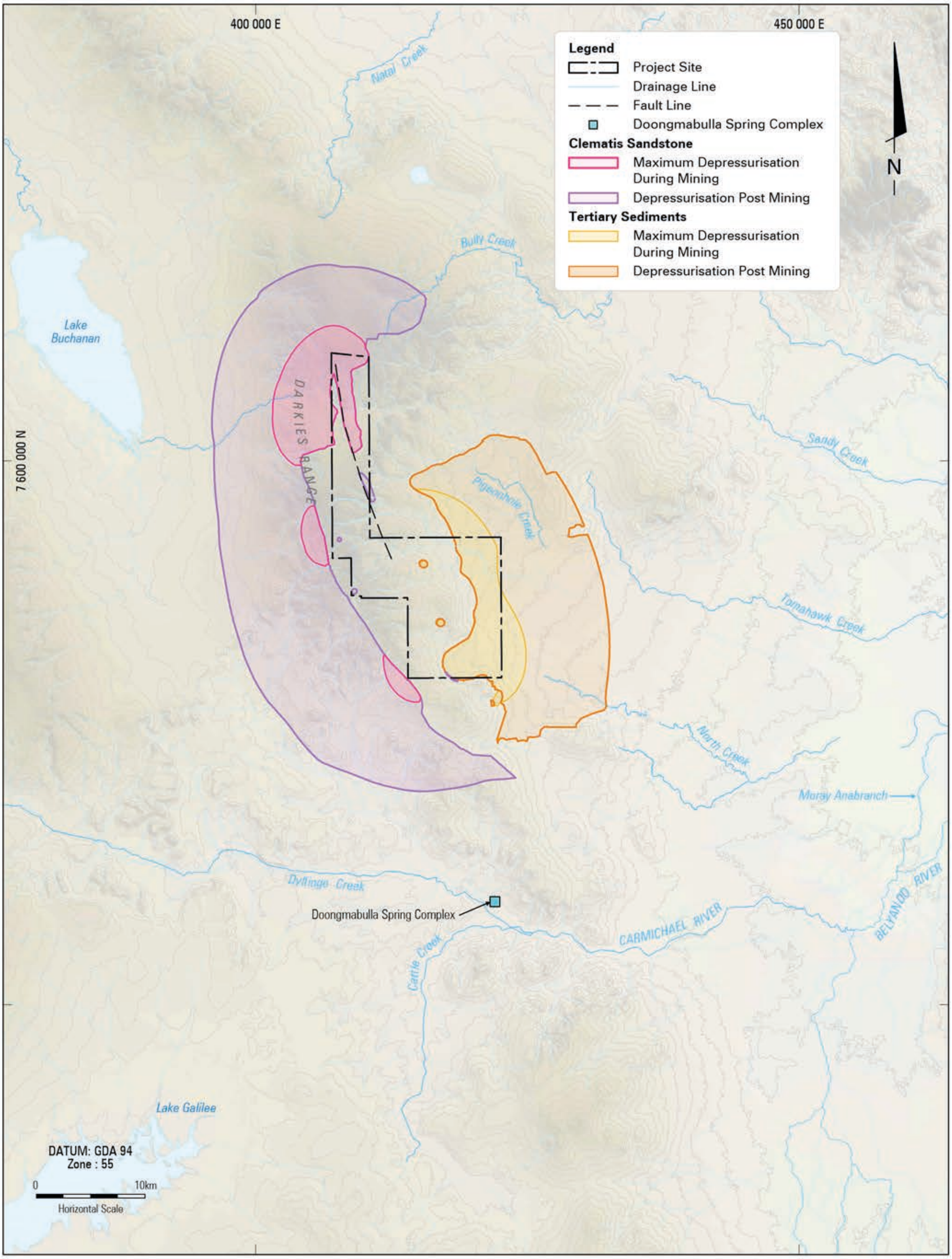
Subsidence Schematic

FIGURE 12-9



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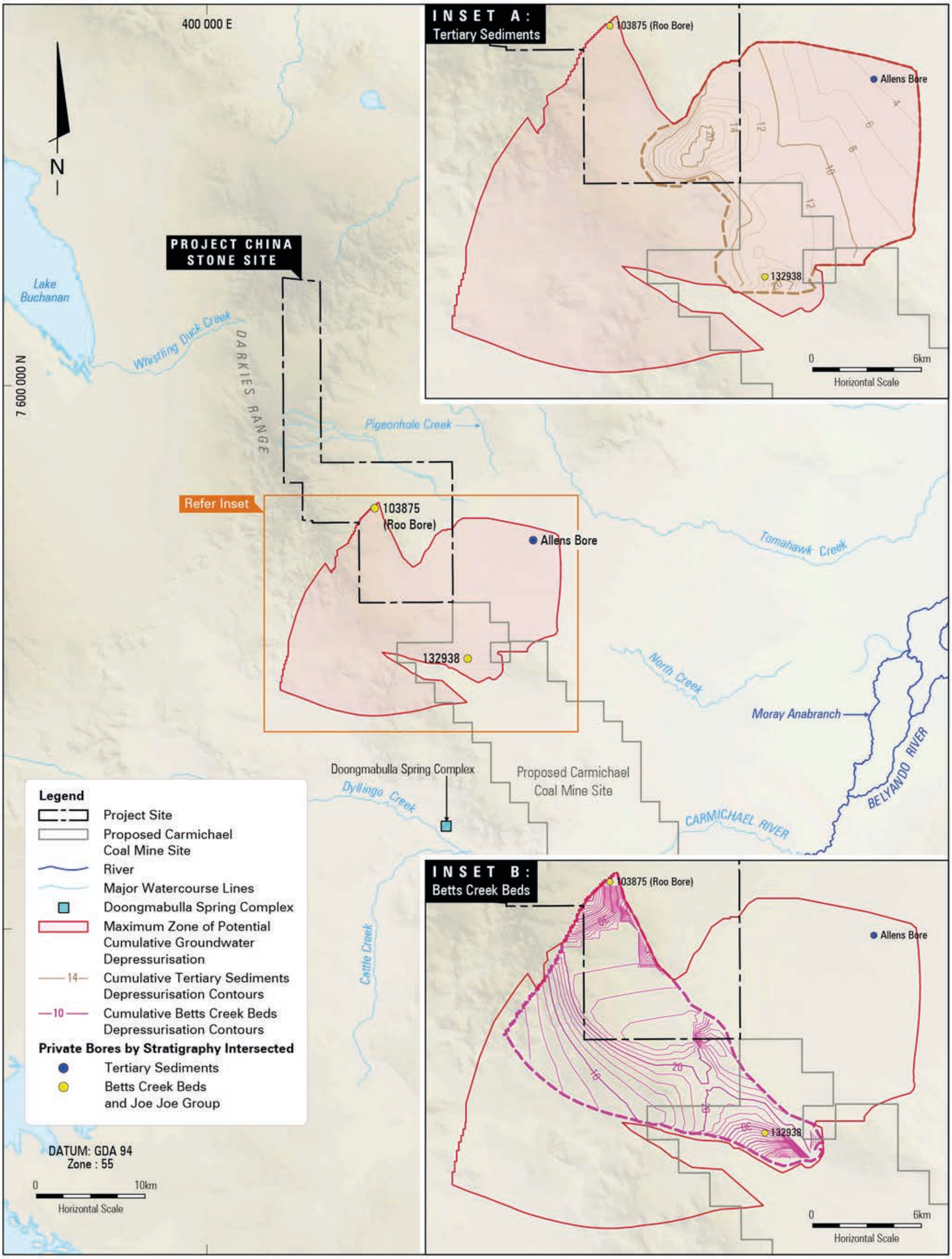
Depressurisation Extents

FIGURE 12-10



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Maximum Predicted Extent of Potential Cumulative Depressurisation

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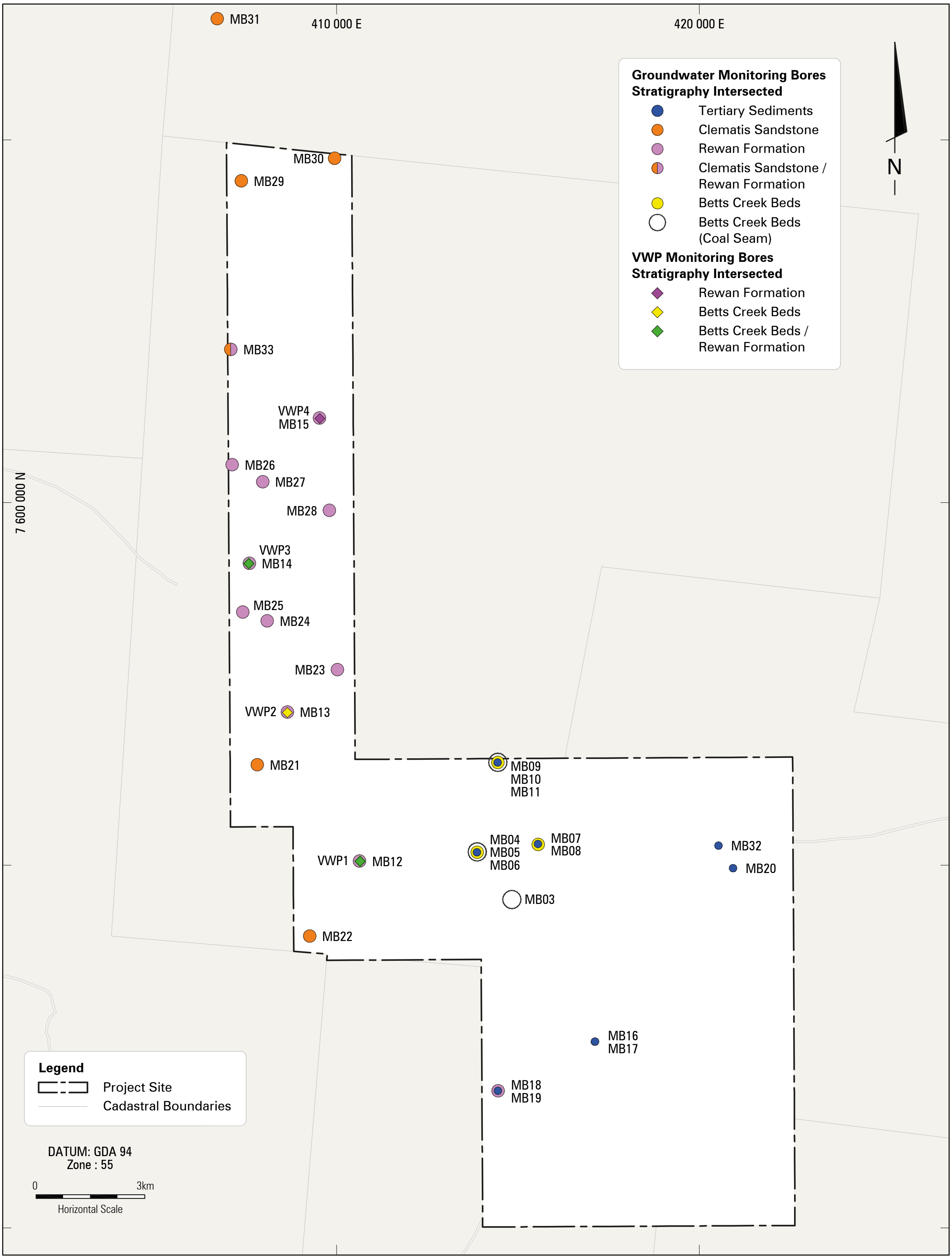
FIGURE 12-11



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Groundwater Monitoring Program

FIGURE 12-12