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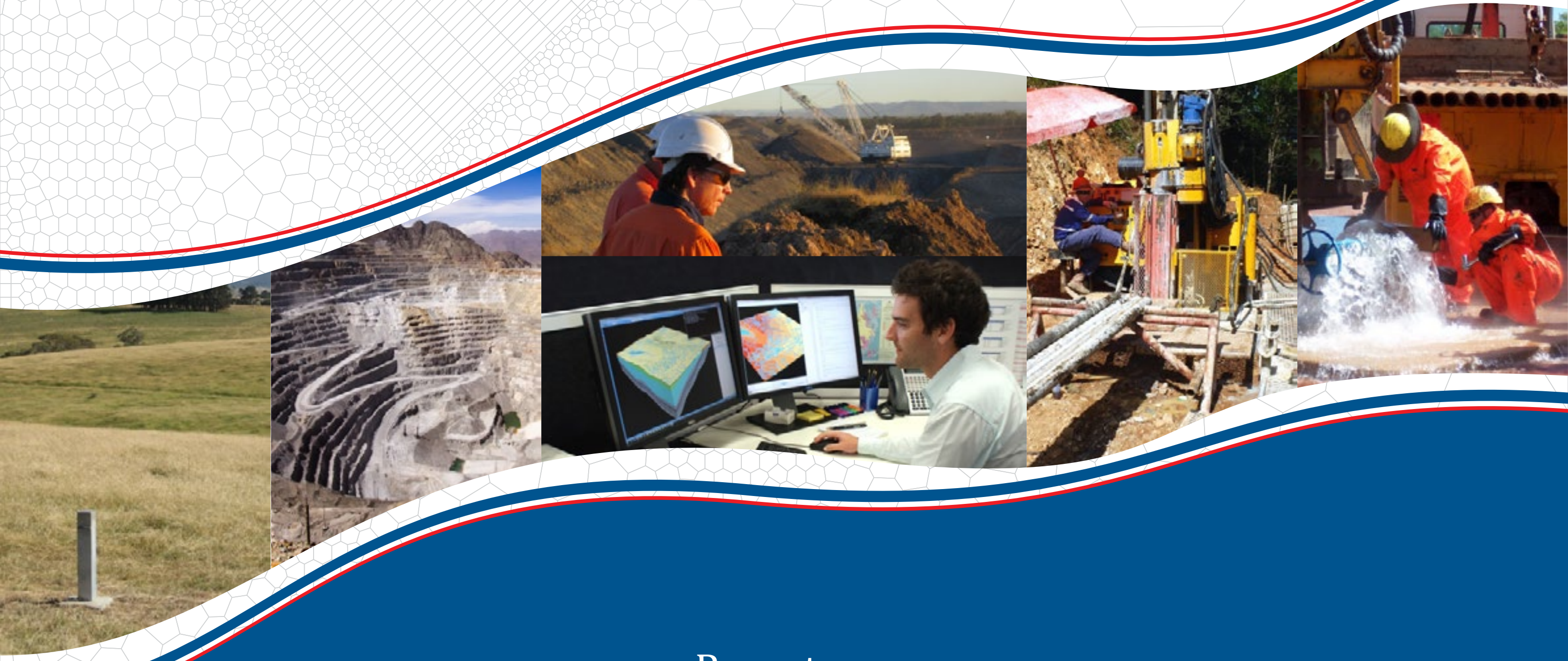
Groundwater Report

Australasian Groundwater and
Environmental Consultants Pty Ltd



Report on

Aurukun Bauxite Project
Groundwater Impact Assessment

Prepared for
Glencore Bauxite Resources Pty Ltd

Project No. G1868J May 2023
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Report on

Aurukun Bauxite Project
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1 Introduction

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) was commissioned on behalf of Glencore Bauxite Resources Pty Ltd to complete a groundwater impact assessment as part of the Environmental Impact Statement (EIS) for the Aurukun Bauxite Project (the project).

1.1 Project Description

The project involves the construction and operation of an open cut bauxite mine and associated infrastructure on a greenfield site in western Cape York, Queensland (Figure 1). The mine's peak production rate would be up to 15 million tonnes per annum (Mtpa) of run of mine (ROM) bauxite ore, which equates to up to eight million dry tonnes per annum (Mdtpa) of product bauxite. The mine life would be approximately 22 years.

Figure 2 shows the location of key project infrastructure and the proposed mining lease area (also termed the "project site"), which covers an area of approximately 23,100 ha. The following activities would be undertaken as part of the project:

- Developing open cut mining areas within the Mine Site and mining bauxite ore using bulldozers and front end loaders. Mined areas would be progressively rehabilitated.
- Transporting mined ore in haul trucks from the open cut mining areas to an on-site Beneficiation Plant.
- Screening and washing the bauxite ore in the on-site Beneficiation Plant. The screening and washing process would generate product bauxite, as well as fine grained waste material (termed fines). Fines would be disposed of in a Fines Containment Area (FCA) during the first three years of mining then, subsequently, in designated mining areas where mining activity has been completed.
- Transporting product bauxite by road train from the Beneficiation Plant to a Coastal Loading Facility (CLF), to be located approximately 15 km to the west of the Mine Site. A sealed road, termed the Product Haul Road, would be constructed to connect the Mine Site and the CLF.
- Using a Load-out Jetty at the CLF to load product bauxite, direct from road trains and/or via stockpiles, on to a Transhipment Vessel.
- Transporting the product bauxite via a Transhipment Vessel to Ocean Going Vessels that would be moored approximately 18 km offshore. The Ocean Going Vessels would then ship the product bauxite to international markets.

Infrastructure required as part of the project includes conveyors, stockpiles, workshops, warehouses, administration buildings, vehicle servicing, refuelling and wash down facilities, fuel storage facilities, power supply infrastructure, an incinerator and an accommodation village. It would also be necessary to construct water supply and management infrastructure, including a dam on Tapplebang Creek.

The project site includes the following component areas, which are shown on Figure 2:

- The Mine Site, which is located within Mineral Development Licence (MDL) 2001.
- An area to the west of MDL 2001 that will connect the Mine Site to the coast. This area encompasses the proposed Product Haul Road and the CLF and is termed the Product Bauxite Transport Corridor.

1.2 Scope of Assessment

The proposed open cut mining activities are located within the Mine Site. No mining will be undertaken within the Product Bauxite Transport Corridor and there is negligible potential for activities at the Product Haul Road and the CLF within the Product Bauxite Transport Corridor to result in groundwater impacts. Hence, while the groundwater study provides a holistic description of the project's groundwater setting, the groundwater impact assessment is focussed on the Mine Site.

The scope of work for the groundwater assessment included:

- Reviewing relevant reports to develop an appreciation of the geological and hydrogeological setting of the project;
- Reviewing relevant geological data including 3D geology models, databases, and exploration drilling logs developed by the proponent;
- Reviewing government databases for data related to groundwater, climate, surface hydrology, ecology and geology;
- Undertaking a census of groundwater supply bores within a 5 km radius of the project site to confirm bore locations, usage, and water quality;
- Undertaking a groundwater site investigation to develop a detailed understanding of the groundwater regime at the Mine Site including drilling and installation of dedicated monitoring bores, the measurement of groundwater levels and groundwater quality, inspection of creek beds for lithology characteristics, and testing of aquifer hydraulic parameters in relevant strata;
- Compiling a groundwater monitoring dataset from the available data. Data was collected for a range of hydraulic parameters including groundwater levels, yield, permeability, and groundwater quality;
- Analysing the available data and using it to develop a conceptual model of the groundwater regime of the Mine Site and surrounding areas;
- Developing a 3D numerical flow model for predictive simulation of the scale and extent of project impacts upon groundwater levels during mine operations and post-closure;
- Assessing the groundwater impacts and developing feasible mitigation and management strategies, where necessary; and
- Developing a groundwater monitoring program for the project.

1.3 Report Structure

This report is structured as follows:

- Section 1: Introduction – provides an overview of the project and describes the assessment scope and report structure;
- Section 2: Regulatory Framework – describes the relevant regulatory requirements relating to groundwater;
- Section 3: Project Setting – describes the environmental setting of the project including land use, topography, drainage, climate, and geology;
- Section 4: Methodology – describes the assessment method, including the desktop study, the site investigation, and the numerical modelling methods;
- Section 5: Existing groundwater regime – describes the existing groundwater regime of the Mine Site and its surrounds, including the hydrostratigraphy;
- Section 6: Impact Assessment – provides a detailed description of the proposed mining activities and the predicted effects of mining 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;
- Section 7: Groundwater Monitoring and Management – describes the proposed groundwater monitoring program for the project; and
- Section 8: Conclusions.

Appendix A provides a detailed description of the site investigation undertaken as part of this assessment including the investigation methods, monitoring bore construction details, groundwater levels, hydraulic data, and the groundwater quality parameters collected from monitoring bores during the site investigation.

- Appendix B presents the details of all groundwater monitoring bores used in this assessment.
- Appendix C presents the compiled groundwater quality dataset used in this assessment.
- Appendix D provides a detailed description of the numerical modelling undertaken for the project, including details on model construction, calibration, prediction, and sensitivity analysis.
- Appendix E presents predicted water levels near creeks and other features relevant for aquatic ecology.
- Appendix F presents predicted water levels beneath locations relevant for terrestrial ecology.

2 Queensland Regulatory Framework

2.1 Underground Water Management Framework

The Queensland *Mineral Resources Act 1989* (MR Act) entitles the holder of a mining lease to take or interfere with underground water (i.e. groundwater) as part of approved mining operations. This entitlement is termed the mining lease holder's 'underground water rights'.

Groundwater that is taken or interfered with while exercising the underground water rights is termed 'associated water'. The holder of the mining lease is entitled to use associated water for any purpose. In order to exercise the underground water rights for the project, the lease holder must:

- Obtain an Environmental Authority (EA) under the Queensland *Environmental Protection Act 1994* (EP Act);
- Comply with the notification requirements under Section 334ZP(6) of the MR Act by notifying the administering authority for Chapter 3 of the Queensland *Water Act 2000* (Water Act) of the exercise of its underground water rights. The administering authority for Chapter 3 of the Water Act is the Department of Environment and Science (DES); and
- Comply with its monitoring and reporting obligations under Section 334ZP(5) of the MR Act and Chapter 3 of the Water Act. Section 334ZP(5) of the MR Act requires that the volume of associated water taken is measured and reported. Obligations for the lease holder under Chapter 3 of the Water Act include undertaking baseline assessments of the groundwater regime and water supply bores, providing ongoing assessment and reporting of groundwater take and (where necessary) entering into make good agreements with owners of affected water supply bores.

In order to obtain an EA, Section 126A of the EP Act requires that the EA application for the project must be supported by the following information regarding the exercise of underground water rights:

- A statement describing the proposed exercise of underground water rights and a description of the timing and location of the proposed activities;
- A description of each aquifer and the movement of water within each aquifer affected by the proposed activities;
- An assessment of the extent of depressurisation in each aquifer due to the proposed activities;
- The predicted quantity of associated water taken from each aquifer during the proposed activities;
- A description of the impacts of the proposed activities on environmental values;
- A description of the effects of the proposed activities on groundwater quality; and
- A description of any strategies to manage or mitigate the impacts of the proposed activities.

The supporting information required under the EP Act is provided in this report. The proposed exercise of underground water rights is discussed in Section 6.1. The conceptual groundwater regime, including relevant aquifers and the movement of groundwater is discussed in Section 5. The predicted effects of the project, including changes in groundwater levels and groundwater take are discussed in Section 6.3. The predicted project and cumulative impacts on groundwater users and sensitive environmental features are addressed in Section 6.4 and Section 6.5. The project impacts on groundwater quality are addressed in Section 6.6. Groundwater monitoring and management is discussed in Section 7.

In accordance with the requirements of the MR Act, the proponent will notify DES of its exercise of underground water rights on the Mine Site immediately after it starts exercising the rights. The proponent will report the annual associated water volume taken in accordance with the Guideline *Quantifying the volume of associated water taken under a mining lease or mineral development licence*.

If underground water rights are exercised, in accordance with the requirements of Chapter 3 of the Water Act, the proponent will:

- Prepare an Underground Water Impact Report (UWIR). The main purpose of the UWIR is to describe the groundwater take due to mining (and any associated impacts) over a three-year period. The UWIR will also include a process for annual review and reporting. The UWIR will be prepared in accordance with Section 376 of the Water Act and the DES guideline *Underground water impact reports and final reports* (the UWIR guideline), where relevant. Consistent with the UWIR guideline, the information supplied in support of the EA approval process under the EP Act will be used as the basis for the UWIR. The proponent will consult on the draft UWIR and notify relevant landholders. The draft UWIR will be provided to DES prior to the proponent exercising its underground water rights.
- Prepare a Baseline Assessment Plan (BAP) for any water supply bores located on the Mine Site. Section 6.1 (of this report) explains that there are no water supply bores located on the Mine Site and hence a BAP will not be required for the project. If a water supply bore is subsequently identified on the Mine Site, the proponent will notify DES and prepare a BAP.

2.2 Other Groundwater Legislation and Approvals

2.2.1 Water Resource Planning

The water resource planning process under the Water Act provides a framework for the development of catchment specific Water Plans. A Water Plan, along with Water Management Protocols, and associated operations manuals, 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.

The project site is located in the *Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017* (the GABORA Water Plan) and the *Water Plan (Cape York) 2019* (the Cape York Water Plan) areas.

The GABORA Water Plan comprises several regulated 'groundwater units' and 'groundwater sub-areas'. The project site is located within the following GABORA Water Plan regulated groundwater units and sub-areas (as shown in Figure 3):

- The Cape Gilbert River Aquifer sub-area of the Hooray Groundwater Unit;
- The Cape Rolling Downs sub-area of the Rolling Downs Groundwater Unit.

The Cape York Water Plan area is divided into underground water management areas. The project site is located in the Cape York Underground Water Management Area.

The project impacts on regulated groundwater resources are addressed in Section 6.4.

2.2.2 Water Entitlements

As discussed in Section 2.1, the proponent has the right to take associated water under the MR Act. Hence, a water entitlement under the Water Act (e.g. a water allocation or water licence) is not required for associated water take.

Groundwater taken for 'consumptive' non-mining purposes (such as construction work and supplying accommodation camps) is not associated water. Hence, it is not authorised under the MR Act and would require a water entitlement. The project does not involve groundwater take for consumptive non-mining purposes and therefore a water entitlement is not required.

2.2.3 Environmental Values and Water Quality Objectives

The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water) provides a framework for the protection of environmental values (i.e. uses) associated with Queensland aquifers. Under this framework, environmental values for specific catchments and drainage basins have been formalised through a process of statutory declaration. Environmental values formalised in this way are listed in Schedule 1 of the EPP Water. For other waters, a site specific assessment of the potential environmental values is required.

The project site and its surrounds (including the Ward River catchment and its tributary catchments, the Norman Creek catchment or the local coastal catchments) are located within Drainage Basin 923 (i.e. the 'Watson Basin'). To date, no environmental values have been declared for this basin.

The Watson Basin is considered to be environmentally and culturally sensitive. The groundwater resources of the Watson Basin currently support a range of surface water environmental values, including aquatic ecosystems and human uses, which are described below.

The existing surface water environmental values of the Ward River catchment and its tributary catchments, the Norman Creek catchment or the local coastal catchments, have been identified from a review of known land and water uses within the catchment, stakeholder consultation, and through reference to published information. The groundwater regime interacts with surface water in these catchments and the environmental values are therefore relevant to the groundwater assessment.

A detailed ecological assessment of the project's catchment setting was undertaken as part of the EIS Aquatic Ecology Report. This assessment indicates that the Ward River and its tributaries are considered to be ecologically undisturbed and of high ecological value.

The EIS Social Impact Assessment Report provides a detailed description of surface water use by locals. The social impact assessment shows that the Ward River and its tributaries are frequently used by locals on day trips, overnight camping or camping over extended periods. Locals use these creeks for drinking water, hunting and fishing for food, recreation activities (such as swimming) and cultural practices. Locals also collect natural resources such as roots, bulbs, leaves, wood and plants from riparian areas associated with these creeks.

The Ward River traverses the Amrun Mine site downstream of the project site boundary (Figure 4). The Amrun Mine operator (Rio Tinto) has approval to abstract surface water from the Ward River for use as a mine water supply, although the Amrun Mine abstraction site has not yet been constructed. The approved future abstraction site location is shown in Figure 4. Rio Tinto also operates a borefield currently comprising six bores to extract groundwater for use as a mine water supply. The borefield location is shown in Figure 4.

In summary, the groundwater environmental values relevant to the project are:

- High ecological value aquatic ecosystems;
- Recreational use, including swimming and aesthetic values;
- Human consumption of aquatic foods;
- Drinking water supply;
- Cultural values; and
- Industrial use (from the Amrun Mine groundwater supply borefield and the approved future Amrun Mine surface water abstraction).

Water quality values associated with farming, agriculture and aquaculture are not relevant because no such activities are undertaken within the Ward River catchment.

The groundwater users and sensitive environmental features within the project site and its surrounds are described in Section 5.

The EPP Water also establishes water quality objectives (WQOs) to protect the relevant environmental values of surface water and groundwater. WQOs are quantitative measures or narrative statements established to protect relevant environmental values. WQOs comprise water quality indicators and corresponding water quality guidelines. The water quality indicators are the physical, chemical or biological properties that can be quantitatively measured, while the water quality guidelines are the quantitative measure for an indicator.

WQOs have been established for the same catchments and drainage basins that have been formally assigned environmental values (through the process described above). WQOs that have been formalised in this way are listed in Schedule 1 of the EPP Water. For other waters (not listed in Schedule 1 of the EPP Water), WQOs are determined using site-specific information and other relevant documents including the *Queensland Water Quality Guidelines* (QWQG; DEHP, 2009), the *Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC & ARMCANZ, 2000, updated 2018), the *Australian drinking water guidelines* (NHMRC, 2011), and the *Guidelines for managing risks in recreational waters* (NHMRC, 2008).

To date, no WQOs have been declared for the Watson Basin including the Ward River catchment (or its tributary catchments), the Norman Creek catchment, or the local coastal catchments.

In the absence of declared WQOs, the EPP Water requires that high ecological value waters should be managed to ensure that there is no change in water quality and hence the condition of the natural aquatic ecology values is maintained. No change in groundwater quality is deemed to have occurred if:

- For pH and dissolved oxygen, the median recorded value remains within the 20th and 80th percentile range of the natural distribution of groundwater data; and
- For all other parameters, there is no detectable change to the 20th, 50th and 80th percentiles of the natural distribution of groundwater data.

The site-specific baseline groundwater quality results presented in Appendix C will provide the basis for the percentiles required for the development of site-specific groundwater quality guidelines that support the management intent of the EPP Water for high ecological value waters. Appendix C also provides generic guideline values relevant to the water uses identified above.

3 Project Setting

This section describes the regional and local setting of the project and discusses the location, land use, climate, terrain, and geology of the Mine Site.

3.1 Location and Land Use

The project site is largely undeveloped. Bauxite exploration has been undertaken within the Mine Site at various times since the 1950s. A derelict airfield is located in the Mine Site.

The majority of the Mine Site supports remnant vegetation, comprising mostly eucalypt tall woodlands with scrubby woodland to open forest fringing the watercourses that traverse the project site. There is no evidence of clearing for agriculture or farming within the project site or its surrounds. The project site is currently utilised by locals for cultural practices, recreation, fishing and hunting.

Mining Lease (ML) 7024 adjoins the western boundary of the Mine Site. ML 7024 is held by Rio Tinto. ML 7024 is the mining lease for the Amrun Mine, as well as much of Rio Tinto's Weipa mining operations. The Product Bauxite Transport Corridor is located within ML 7024. The proponent intends applying for a ML over the full extent of the Mine Site and parts of the Product Bauxite Transport Corridor. Figure 4 shows the location of the project site relative to the Amrun Mine site.

The Amrun Mine is currently under construction. The approved Amrun Mine operations comprise several open cut bauxite mining areas. Key infrastructure for the Amrun Mine includes a water supply dam (called Arraw Dam) and a groundwater supply borefield. The approved Amrun Mine open cut mining areas and infrastructure are located within ML 7024.

The Amrun groundwater supply borefield currently comprises six bores located approximately 6 km to 15 km west and northwest of the project's open cut mining areas (Figure 4). The Amrun groundwater supply borefield targets the Gilbert River Formation and Garraway Sandstone. The licensed groundwater take from the Amrun groundwater supply borefield is a five-year moving average of 12 Gigalitres per annum (GL/a), with a maximum of 15 Gigalitres (GL) in any one year.

The potential impacts of the project on the operation of the Arraw Dam and the Amrun groundwater supply borefield are addressed in Section 6.4.3 and 6.4.2, respectively. The potential for cumulative impacts due to the project and the surrounding land uses is assessed in Section 6.5.

3.2 Topography and Drainage

The local topography and surface drainage are shown in Figure 5.

The dominant landform is low lying and gently undulating coastal plains, with deeply incised gullies associated with lower reaches of streams and rivers. Upland areas are plateaued, and low rises in the undulating landscape create local catchment divides.

The project is located in the regional catchment draining to Archer Bay, which drains into the Gulf of Carpentaria at Aurukun Township. Archer Bay collects runoff from the Archer River, Watson River, Tompaten Creek and the Ward River. The Ward River is the smallest catchment draining to Archer Bay. A prominent topographic rise divides the Ward River catchment from the Hey River catchment to the northeast.

The Mine Site is drained by Tapplebang Creek, Coconut Creek and a tributary of Norman Creek.

Norman Creek drains in a westward direction, to the Gulf of Carpentaria approximately 35 km north of Archer Bay. The Amrun Mine is located within the Norman Creek catchment.

Tapplebang Creek and Coconut Creek are ephemeral creeks that traverse the project site. Coconut Creek flows in a south-western direction, joining Tapplebang Creek to become the Ward River approximately 9 km from the project site boundary. The Ward River drains in a southward direction to Archer Bay.

Most surface water flows occur in the wet season, mirroring rainfall distribution. Baseflow, which is supported by groundwater that seeps into the Ward River catchment watercourses, may continue for several months following the end of the wet season.

The EIS Aquatic Ecology Report has identified several groundwater seeps and wetlands within the project site and its surrounds (Figure 5), including the following:

- Sites AQ3, AQ5, AQ12 and AQ25 are groundwater seeps located on Coconut Creek.
- Sites AQ17 and AQ21 are groundwater seeps located on Tapplebang Creek.

3.3 Climate

The local climate is tropical, with two distinct seasons: a monsoonal wet season from November/December to March/April, typified by high humidity, temperature and evaporation rates; and a slightly cooler dry season during the remainder of each year. The project site regularly experiences tropical cyclones (TCs) during the wet season.

Rainfall data from 2008 to 2019 are shown in Figure 6, based on the following sources:

- January 2008 to December 2018: Bureau of Meteorology (BoM) station 027000 (25 km south of the Mine Site);
- May 2018 to October 2018: BoM station 027045 (40 km north of the Mine Site); and
- December 2018 to May 2019: rain gauges located within the project site.

The average annual rainfall over this period is 1,705 mm. The majority (98%) of the rainfall occurs during the wet season. The average monthly rainfall is typically the highest in February, and lowest in July.

Figure 6 also presents the cumulative rainfall departure (CRD). The CRD shows that monthly rainfall was average or below-average between 2014 and 2018. In 2019, the CRD was above average due to several large rainfall events, including TC Trevor.

Long-term (1961–1990) actual areal evapotranspiration (AAET) for the project site was sourced from BoM data. The AAET is 1,031 mm/yr. The monthly average AAET is shown in Figure 7. Average annual rainfall (1,705 mm) exceeds evapotranspiration (1,031 mm/yr), producing conditions that are favourable to groundwater recharge.

3.4 Geology

The project site is located on the eastern flank of the Carpentaria Basin, a sedimentary basin comprising Jurassic to Cretaceous age geology. During the late Cretaceous period, a recession in global sea levels exposed the Carpentaria Basin sediments to erosion. The Carpentaria Basin sediments were subsequently redeposited under fluvio-deltaic conditions, forming the Bulimba Formation.

During the Tertiary period, the Bulimba Formation was extensively modified by a long period of tropical weathering (or laterisation). The weathering process resulted in the development of a deep weathered profile (or laterite). The weathered profile thickness ranges from approximately 13 m to 32 m in the Mine Site. The upper weathered profile includes the target bauxite ore.

The surface geology in the Mine site and its surrounds is shown in Figure 8. Figure 9 shows typical geological cross-sections through the Mine Site.

The Mine Site stratigraphy includes the following (in descending order):

- Bauxite ore;
- Weathered Bulimba Formation sediments;
- Fresh (i.e. unweathered) Bulimba Formation sediments; and
- Underlying strata of the Carpentaria Basin, including the Rolling Downs Group and deeper formations.

The bauxite ore is an alumina-rich sedimentary rock that mainly comprises the minerals gibbsite, boehmite and ferricrete. The bauxite ore texture grades from loose, granular pisolite to cemented, massive pisolite. The bauxite ore is widely distributed over the Mine Site. Where present, the bauxite ore is typically located at, or within 1 m of, the ground surface. The bauxite ore is between 1 m and 13 m thick in the elevated parts of the Mine Site and is typically absent in and adjacent to the lower lying creeks. The bauxite ore is between 2 m and 13 m thick in the open cut mining areas.

The bauxite ore is typically covered by a thin veneer of topsoil and subsoil that is up to approximately 1 m thick.

The weathered Bulimba Formation comprises kaolinite and clay-rich sediments (silty clay, sandy clay). The weathered Bulimba Formation is present across the entire Mine Site and underlies the bauxite ore (where present). The weathered Bulimba Formation is up to approximately 30 m thick in the elevated parts of the Mine Site and is thinner (approximately 7 m thick) below the lower lying creeks. The weathered Bulimba Formation is approximately between 7 m and 27 m thick in the open cut mining areas.

The fresh Bulimba Formation is typically siltstone, with minor clayey quartzose and feldspathic sandstone. The fresh Bulimba Formation underlies the weathered Bulimba Formation across the entire Mine Site. The fresh Bulimba Formation is approximately 10 m to 20 m thick within the Mine Site.

Historical bore logs show that, in the vicinity of the Mine Site, the Rolling Downs Group is a single undifferentiated formation comprising siltstone, claystone and shale. The Rolling Downs Group outcrops approximately 0.5 km to 2 km northeast of the Mine Site and dips gently towards the west. As the Rolling Downs Group dips to the west, its depth and thickness increase. The top of the Rolling Downs Group is located at a depth of up to 40 m below ground surface under the Mine Site. The Rolling Downs Group is up to approximately 970 m thick within the Mine Site.

The fresh Bulimba Formation is lithologically similar to the upper profile of the Rolling Downs Group and these formations are typically indistinguishable in the field.

The deeper formations of the Carpentaria Basin are not relevant to this assessment and are not discussed in this report.

4 Methodology

This section describes the groundwater assessment methodology. A detailed description of the site investigation methods and findings is provided in Appendix A. Appendix D provides a detailed description of the numerical modelling methods used for the project, including details on model construction, calibration, predictions, and sensitivity analysis.

4.1 Desktop Study

4.1.1 Groundwater Bore Database Searches

A search of relevant Australian and Queensland groundwater databases was undertaken. The purpose of this search was to identify the presence of current and historical groundwater bores and collate drilling records and groundwater level, yield and quality data from relevant bores.

The database search area included the Mine Site and its surrounds within a radius of 20 km. The database search area was considered suitably representative of the geological and hydrogeological setting of the project.

The following groundwater databases were searched:

- The Department of Regional Development, Manufacturing and Water (DRDMW) Groundwater Database of registered groundwater bore data from private water bores and Queensland Government groundwater investigation and monitoring bores (including bore locations, construction details, stratigraphic logs, groundwater levels, hydraulic test data and groundwater quality); and
- The BoM database of groundwater levels and quality.

The data from groundwater bore databases were collated (Appendix B) and used to assess site geology, groundwater levels, and groundwater quality. Other existing and historical groundwater bores that are not listed on the groundwater databases (e.g. unregistered bores, the proponent's project site investigation bores, etc.) have been identified through searches of publicly available reports and approvals documents (as described in Sections 4.1.2 to 4.3). For ease of referencing, all groundwater bores used in this report are summarised in this section and listed in Appendix B.

The existing and historical groundwater bores identified within the 20 km radius of the Mine Site boundary are shown in Figure 10. A total of 105 groundwater bores were identified, of which 40 are within the Mine Site boundary and 65 are outside the Mine Site boundary. The available information on these bores is tabulated in Appendix B.

The 40 groundwater bores within the Mine Site comprise:

- The 22 groundwater monitoring bores installed by the proponent as part of the project. These are summarised in Section 4.2 and discussed in detail in Appendix A.
- Two deep government groundwater investigation bores (RN37291 and RN37630) installed by the State government during the 1970s. These bores are constructed in the deep formations of the Carpentaria Basin below the Rolling Downs Group. DRDMW bore records indicate that these bores are artesian. These bores are recorded on the DRDMW Groundwater Database as abandoned but usable. However, as discussed in Section 4.3, site inspections have confirmed that these bores are unusable.
- Three water supply bores that are recorded as existing, comprising:
    - Beagle Camp Bore (RN109417). This bore was drilled in 2001 in order to provide water supply to exploration activities. Site inspections have confirmed that Beagle Camp Bore has been damaged by bushfires and is disused.

    - RN37199 and RN37200. This pair of bores were drilled in 1969 in order to provide water supply to exploration activities. Site inspections have confirmed that these water supply bores have been destroyed and are no longer present.
- 13 uncategorised bores, including:
    - RN92263 (named BMR Exploration Bore) that is recorded as existing. This bore was drilled in 1971 as part of a government geological exploration program. RN92263 is not a water supply bore.
    - 12 bores (RN92233, RN92234, RN92235, RN92236, RN92237, RN92238, RN92242, RN92244, RN92245, RN92246, RN92247, and RN92248) that have been abandoned and/or destroyed. It is understood that these bores were drilled in the early 1970s as part of government geological exploration programs that were undertaken at that time and these bores have not been encountered onsite.

The 65 groundwater bores outside the Mine Site boundary include:

- Seven artesian water supply bores (RN171544, RN171899, RN171900, RN171901, RN171915, RN171916, RN171930). One of these bores (RN171901) is recorded as abandoned. The remaining six bores collectively comprise the Amrun Mine groundwater supply borefield (as shown in Figure 10). The Amrun Mine groundwater supply bores are located between 6 km and 15 km west of the Mine Site and target the deep sediments of the Carpentaria Basin (typically the Gilbert River Formation) at depths of up to approximately 1 km below ground level. The Amrun Mine groundwater supply borefield is discussed in Section 6.4.2.
- Four shallow sub-artesian water supply bores, including:
    - RN109420 located approximately 4 km south of the Mine Site, adjacent to Sandy Creek. This bore is 60 m deep and targets the shallow Rolling Downs Group.
    - RN109418 located approximately 15 km west of the Mine Site and approximately 3 km south of the Product Bauxite Transport Corridor. RN109418 is located on the coast and targets the weathered Bulimba Formation.
    - RN109419 located approximately 15 km southwest of the Mine Site and approximately 12 km south of the Product Bauxite Transport Corridor. RN109419 is located on the coast and targets the weathered Bulimba Formation.
    - RN171428 located approximately 10 km west of the Mine Site and close to the Amrun Mine groundwater supply borefield (Figure 10). RN171428 targets shallow sediments above the Bulimba Formation in the Amrun Mine site.
- 40 groundwater monitoring bores comprising:
    - 15 DRDMW-registered groundwater monitoring bores within the Amrun Mine site (Figure 10). These bores are sub-artesian and all less than 30 m deep, targeting the weathered Bulimba Formation or overlying sediments present in the Amrun Mine site.
    - 25 unregistered groundwater monitoring bores (labelled Bore 1 to Bore SOE10 in Figure 10) installed in the Amrun Mine site as part of the South of the Embley Project (now Amrun Mine) EIS. These bores are sub-artesian and are inferred to target the weathered Bulimba Formation.
- 14 uncategorised bores including:
    - Nine historical bores (RN23796, RN23999, RN45576, RN45577, RN92249, RN92250, RN92251, RN92252, RN92253) that have been abandoned or destroyed.
    - Four existing bores (RN92255, RN92256, RN92264 and RN92265). These bores are located to the north and southeast of the Mine Site. The closest bore is approximately 3.4 km southeast of the Mine Site. These bores were drilled in 1971 and are understood to have been part of the government geological exploration program undertaken at that time.

  - Bore RN171429 located within the Amrun Mine site, approximately 11 km west of the Mine Site. This bore was drilled in 2016 and is expected to be a groundwater monitoring bore associated with the Amrun Mine.

It should be noted that the DRDMW records show that the town water supply bores for Aurukun are located 24 km south of the Mine Site boundary (Figure 10).

4.1.2 Other Database Searches and Government Mapping

Supporting data were also collected from a search of the following databases and maps:

- Queensland state geological mapping and explanatory notes;
- BoM climate data online (precipitation and evapotranspiration data used in groundwater modelling);
- DRDMW records for stream discharge from state gauging stations; and
- DRDMW records for spring locations and types.

Climate data were compiled and analysed to inform the project setting and to provide inputs to the numerical modelling. Databases regarding water management and regulation were accessed to ensure that this report meets the legislative requirements for assessing impacts to prescribed resources.

4.1.3 Literature Review and Previous Groundwater Studies

The available literature and relevant groundwater studies were reviewed to collect hydrogeological data, and inform the conceptual groundwater model of the project and its surrounds. The following geological and groundwater reports were reviewed:

- Geology & Resource Estimation Aurukun Bauxite Deposit Cape York, Queensland (Mining Associates, 2009). This report provided details of the Aurukun bauxite profile, including the distribution and thickness of bauxite in the Mine Site.
- The South of the Embley Project EIS (RTA Weipa Pty Ltd and Rio Tinto Alcan, 2011). This report provided hydrogeological context of the Amrun Mine, which is adjacent to the Mine Site. The information collected included: bore information, the permeability of local geology, groundwater levels, groundwater abstraction information, transpiration rates, conceptualisation of groundwater flow and project impacts, and relationship of water table to subsurface lithology.
- The Skardon River Bauxite Project EIS (Greencap and Gulf Alumina, 2016). This report provided hydraulic characteristics of lithologies, recharge rates and how they vary with mining activities.
- The Bauxite Hills Project EIS – Hydrogeological Investigation Report (AGE, 2011). This report provided information on the hydraulic parameters of stratigraphic units, and details of lithology layers in a similar setting.
- The Bauxite Hills Project EIS – Groundwater Technical Report (Metro Mining and CDM Smith, 2016). This report provided background information on the hydraulic parameters of stratigraphic units through previous studies conducted in the area, and explanation of macropore structures and their influence on permeability.
- Weipa Shallow Aquifer Recharge Study, Stage 2 and 3, Final Report (Crees and Volker, 1992a and 1992b). These reports provided background information on the hydraulic parameters of stratigraphic units.
- Landscapes and regolith of Weipa, northern Australia (Taylor *et al*., 2008). This report provided a literature review of bauxite on Cape York, *in situ* bauxite formation processes (chemical weathering relevant to groundwater quality), regional stratigraphy, differences in shallow and artesian groundwater quality, lack of matrix in pisolitic bauxite, and variability of groundwater levels in similar terrain.

- Recharge estimates for an unconfined aquifer affected by surface mining and rehabilitation (Volker and Crees, 1993). This report provided background information on the hydraulic parameters of stratigraphic units and the influence of macropores on permeability.
- Resistivity methods in the search for groundwater, Cape York Peninsula, Queensland (Pettifer and Smart, 1976). This report provided regional geological context for the Mine Site, information on the bauxite stratigraphy, details of porosity and permeability in the Bulimba Formation, and the relationship between the water table elevation with the subsurface lithology units about 20 km northeast of Aurukun township.
- Aurukun Bauxite Project: Groundwater and Surface Water Supply and Impact Assessment (Golder Associates, 2013). This report provided context on surrounding groundwater use at artesian borefields at the Amrun Mine the Weipa (Andoom) Mine, and their potential impacts.
- Sediment size influences habitat selection and use by groundwater macrofauna and meiofauna (Korbel *et al*., 2019). This paper provided context on the influence of lithologies on the presence of subterranean fauna.
- Water balance of a tropical woodland ecosystem, Northern Australia: A combination of micro-meteorological, soil physical and groundwater chemical approaches (Cook *et al*., 1998). This paper provided rates of groundwater recharge, baseflow, and transpiration in tropical woodland dominated by *Eucalyptus tetrodonta* calibrated to field measurements.
- Evapotranspiration from Eucalypt open-forest savanna of Northern Australia (Hutley *et al*., 2000). This paper provided field-based observations of eucalypt and understory transpiration in seasonal tropics.

4.2 Groundwater Site Investigation

The proponent undertook a groundwater site investigation that included:

- Installation of a groundwater monitoring network in November 2017 that comprises 11 monitoring sites (C_MB1 to C_MB11, collectively called the 'C_MB series' bores in this report) located within the Mine Site (Figure 11). Each monitoring site comprises a pair of nested shallow and deep bores (i.e. 22 bores in total) (Figure 11). Shallow bores (suffixed 'B') typically collect data from the bauxite, and the deep bores (suffixed 'A') collect data from the underlying weathered and fresh Bulimba Formation.
- Installation of pressure transducers (dataloggers) in each monitoring bore to record high frequency groundwater level data.
- Hydraulic permeability testing (rising/falling head tests) in each monitoring bore containing sufficient water.
- Initial and ongoing monthly manual groundwater level measurements from each monitoring bore.
- Initial and ongoing monthly collection and analysis of groundwater quality samples from each monitoring bore.

Appendix A provides a detailed description of the groundwater monitoring network and datalogger installation, initial groundwater quality sampling and testing, and hydraulic testing. The groundwater monitoring bore logs (Appendix A1), permeability test analyses (Appendix A2 & A3), and groundwater level data and hydrographs (Appendix A4) are also provided in Appendix A.

The groundwater quality data are presented in Appendix C.

The hydraulic testing results are summarised in Figure 12 and Figure 13.

4.3 Bore Census

An initial bore census was conducted on 20 November 2017. The primary purpose of the initial bore census was to locate and characterise the two deep groundwater investigation bores (RN37291 and RN37630) recorded as abandoned but usable.

The initial bore census involved:

- ground-truthing recorded bore locations and searching for unregistered bores;
- taking photographs of bore locations and headworks;
- recording coordinates of bore locations;
- measuring the groundwater level inside the bore if accessible;
- making observations of the condition and type of bore/headworks; and
- removing data loggers and attempting to access the data.

Additional bore inspections were undertaken incidentally by Australian Cultural Heritage Management and C&R Consulting as part of the fieldwork for the EIS cultural heritage and aquatic ecology studies. The purpose of the additional bore inspections was to confirm the status of the three water supply bores that are recorded as existing within the Mine Site: Beagle Camp Bore (RN109417), RN 37199, and RN37200.

The initial and additional bore census inspections confirmed that:

- The headworks of deep groundwater investigation bores (RN37291 and RN37630) are damaged, and these bores are unusable.
- Beagle Camp Bore is present. It appears that this bore was used historically to supply the camp via two raised water supply tanks. The pumping equipment and tanks have been destroyed by bushfires and this bore has been damaged and is no longer equipped for water supply.
- RN37199 and RN37200 appear to have been destroyed and are no longer present.

4.4 Data Analysis and Conceptualisation

4.4.1 Geology Data

The available geological data was integrated into a single 3D geological model for the project site and its surrounds using Leapfrog geological modelling software.

The detailed lithology logs from the project groundwater monitoring bores (C_MB series) were used as the primary data source. This was integrated with the following data sources (data is listed from most to least preferred source):

- The 3D bauxite ore mapping produced by the proponent from detailed exploration on-site drilling.
- All available lithology or stratigraphy logs from other bores (described in Section 4.1.1 and Appendix B).
- A published geological surface sourced from CSIRO that maps the thickness of the Australian regolith was used where no bore data existed (Wilford *et al*., 2016).

As discussed in Section 3.4, the available geological data show that the fresh Bulimba Formation and the Rolling Downs Group are predominantly siltstone and are indistinguishable in the vicinity of the project. As such, these formations have been modelled as a single geological formation.

The geological model developed for the EIS groundwater study was used to produce ground-truthed mapping (Figure 8) and cross sections (Figure 9).

4.4.2 Groundwater Level Data

Groundwater level data were collated from the 22 project groundwater monitoring bores.

The groundwater level data were used to inform the conceptual hydrogeological model, including:

- assessing seasonality by calculating annual minima and maxima of groundwater levels;
- assessing depth to water contours for wet and dry seasons;
- mapping groundwater elevation (hydraulic head) contours;
- plotting groundwater hydrographs showing the water level relative to the base of bauxite;
- developing scaled cross sections with interpolated water tables for wet and dry seasons; and
- calculating lateral and vertical hydraulic gradients.

In addition, the water table fluctuation method was applied to the annual changes in groundwater levels in order to estimate rates of groundwater recharge. This method involved converting the seasonal water level rise into a recharge height. The recharge height was then expressed as a percentage of rainfall depth.

4.4.3 Groundwater Quality Data

An integrated and scientifically-grounded analysis of the groundwater quality was conducted. A suite of geochemical tools was used to interpret the current groundwater quality and understand the *in situ* processes controlling the solute concentrations. The ionic composition of the water was assessed using a Piper diagram, and the groundwater quality evolution was understood through ionic ratio plots (e.g. solute-chloride signatures) and other plots (e.g. pH vs. EC).

Groundwater quality data were also used in a chloride mass balance to provide a second method for quantitative estimation of groundwater recharge. This method compares the concentration of chloride found in rainwater with the concentration found in groundwater, to estimate the potential rate of groundwater recharge sourced from rainfall.

4.4.4 Permeability Data

The results of the permeability tests are summarised and compared in Section 5. The water level measurements from the tests and the graphical analyses of hydraulic conductivity for each monitoring bore are presented in Appendix A.

4.5 Numerical Modelling

The groundwater model was developed using MODFLOW-USG software, the industry standard for groundwater flow modelling. A detailed description of the modelling method is provided in Appendix D. The model was built around the conceptual groundwater model outlined in Section 5. The model represented the key geological units in a four layer model extending approximately 45 km north-south and 40 km east-west, and comprised 141,475 active model cells in each model layer.

Development of the model was based on the high resolution bauxite surface developed by the proponent. The geological model was further enhanced by inclusion of published lithological logs within the model extents and published geological layers (Section 4.4.1). The model layers were designed to represent the relevant hydrostratigraphic layers, as described in Section 5.

The model extents include the Mine Site, the surrounding areas inside the Tapplebang Creek and Coconut Creek catchments, and the downgradient area to the coast. This area encompasses the Amrun Mine. This approach provides a robust baseline against which the project impacts have been assessed.

The selection of appropriate model boundary conditions, including their locations and alignments, was based on: a detailed review of all available geological and hydrogeological information; topography, and drainage divides; coastline orientation; the project setting relative to groundwater users; and the neighbouring Amrun Mine. Where this information indicated a clear, logical choice of boundary condition, this was selected (i.e. the ocean accepts unlimited groundwater flow from the continent, and this is logically represented as a constant head boundary, set at local sea level). Where the model boundary condition could be interpreted in a number of ways, the alternatives have been considered, and those conditions which represent the most conservative modelling approach in terms of mining impacts were selected. Therefore, by adopting those values which provide the most conservative mining impacts, any potential uncertainty has been accommodated.

The model was calibrated using multiple data sources to achieve the best match in accordance with modelling guidelines (Barnett *et al.*, 2012). The data used for calibration included the groundwater levels collected from high resolution and high frequency measurements at the Mine Site, groundwater levels from single point measurements available from surrounding bores, and calculated baseflow to streams based on surface water monitoring. The model calibration achieved a Scaled RMS error of less than 5%, which is well below the acceptable limit of 10% as recommended by the modelling guidelines (Barnett *et al.*, 2012). The model calibration is therefore considered robust and suitable for addressing the potential groundwater impacts of the project.

Once calibrated, the model was used to predict the groundwater level behaviour in response to simulated mining activities, comprising the progressive stages of: clearing, mining, fines emplacement and rehabilitation. The model simulated mining to the base of the bauxite orebody. The mining was simulated over the proposed project construction and operations phases and for an additional 76 years to capture the return to a new equilibrium after mining activities cease.

The model predicted changes in groundwater levels, flows and fluxes within the model extent. Changes were defined for the predictive model by comparing two iterations a “mining scenario” model run, and a “no-mine scenario” model run. Differences in the results (i.e. levels or flows) of these iterations are the predicted effect of the mining activities on groundwater.

A sensitivity analysis was then used to determine how the model predictions vary when model parameters are varied. 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, specific yield and specific storage and groundwater seepage rates from fines materials. These changes capture extremes in the potential behaviour of the groundwater regime in response to mining activities.

5 Existing Groundwater Regime

5.1 Overview

The local groundwater regime is illustrated in Figure 14 and comprises:

- A shallow lateritic aquifer that includes:
    - The bauxite ore that is typically dry and unsaturated;
    - The weathered Bulimba Formation sediments where the groundwater table is usually located; and
- Undifferentiated strata of the fresh Bulimba Formation the Rolling Downs Group (herein collectively referred to as the fresh Bulimba Formation).

The upper part of the fresh Bulimba Formation is hydraulically connected to the shallow lateritic aquifer. However, the degree of hydraulic connection decreases with increasing depth due to the presence of successive layers of low permeability siltstone, claystone, and shale within the fresh Bulimba Formation that inhibit the vertical movement of groundwater. Overall, the fresh Bulimba Formation acts as an aquitard that is approximately 1 km thick at the Mine Site and confines and hydraulically separates the shallow lateritic aquifer from the deeper formations of the Carpentaria Basin.

The deeper formations of the Carpentaria Basin, including the regulated Cape Gilbert River Formation aquifer and the Cape Rolling Downs aquifer of the GAB are located up to approximately 1 km below ground level in the Mine Site and are overlain by a thick aquitard, and hence are not relevant to this assessment.

The local groundwater regime is characterised by significant seasonal variations in groundwater table depth. The groundwater table fluctuates by up to approximately +/- 10 m over an average annual seasonal cycle (as shown in Figure 15 and Figure 16, which show the average depth to water for each season). In addition, there are spatial variations in the groundwater table depth due to changes in topography, whereby the groundwater table is generally deeper in elevated areas and shallower in the vicinity of incised creeks and tributaries.

The groundwater regime is typically recharged by rainfall that occurs during the wet season. The groundwater table typically rises by up to approximately 10 m in response to wet season rainfall. The groundwater table is typically at its highest (i.e. closest to ground level) a few weeks after the end of the wet season. At this time, the groundwater table depth ranges from ground level to approximately 8 m below ground level across the majority of the Mine Site and its surrounds. The groundwater table intersects the ground surface in the creek beds and in the headwaters of their tributaries. Locally, groundwater flows towards rivers and creeks where it seeps through the bed and high banks and provides baseflow.

As the dry season progresses, the groundwater table becomes progressively deeper. Towards the end of the dry season, when the groundwater table is at its deepest, the depth to groundwater is generally greater than 8 m below ground level across the majority of the Mine Site and its surrounds. The groundwater table typically continues to intersect some sections of the creek beds throughout the dry season.

Groundwater discharge also occurs regionally: at the coast approximately 20 km west of the Mine Site; via evaporation from the shallow aquifer; and via transpiration from woodland vegetation that is present across the majority of the project site and its surrounds.

Groundwater is slightly acidic and non-saline with low concentrations of metals, metalloids, and other solutes.

Sections 5.2 to 5.4 provide a detailed description of groundwater distribution, movement, use and quality in the bauxite, weathered Bulimba Formation, and the fresh Bulimba Formation, along with the hydraulic properties of each formation.

5.2 Bauxite

5.2.1 Groundwater Distribution

The bauxite ore is widely distributed over the Mine Site (Figure 17). Where present, the bauxite ore is typically located at, or within 1 m of, the ground surface. The bauxite ore is between 1 m and 13 m thick in the elevated parts of the Mine Site and is typically absent in the lower lying creeks. The bauxite ore is between 2 m and 13 m thick in the open cut mining areas.

The bauxite is typically dry and unsaturated. Seasonal rises in the groundwater table temporarily saturate the base of the bauxite in localised areas within the Mine Site and its surrounds (Figure 18). The saturated thickness of the bauxite is up to approximately 4 m (Figure 19). The base of the bauxite is typically saturated for less than 8 weeks per year, before the groundwater table drains back into the weathered Bulimba Formation.

5.2.2 Hydraulic Parameters

The hydraulic conductivity of the bauxite is well understood from numerous regional studies. The bauxite has a high permeability. Hydraulic conductivities are as high as 62 m/d (Table 1). The high permeability rates are consistent with the granular texture of the bauxite and the presence of solution cavities (also known as macropores) produced by the high rainfall and tropical weathering processes. Macropores enhance vertical drainage of groundwater through the bauxite, and vertical hydraulic conductivity is known to equal or exceed horizontal hydraulic conductivity in the bauxite. The high permeability of the bauxite is consistent with the temporary saturation and free drainage observed in the bauxite (as discussed in Section 5.2.1).

Macropores are also responsible for the range of bauxite permeability. Permeability values obtained from excavated trenches typically provide better exposure of macroporosity and result in higher permeability values (Table 1). Conversely, boreholes typically intersect fewer macropores and therefore the permeability values obtained from tests on bores are one or two orders of magnitude lower (Table 1).

Table 1 Ranges of bauxite hydraulic conductivity

Hydraulic Conductivity range (m/d)	Data source	Test Site	Location of bauxite tested	Reference
14 – 62	Rising head tests	Trenches	Weipa Mine	Crees and Volker, 1992a
0.15 – 0.1	Falling/rising head tests	Boreholes	Bauxite Hills Project	AGE, 2011
0.25 – 4.5	Falling/rising head tests	Boreholes	Pisolite Hills Project	AGE, 2010
0.007 – 1.9*	Falling head tests	Boreholes	Amrun Mine	RTA Weipa and Rio Tinto Alcan, 2011

Note: ** Bores are screened across bauxite and weathered Bulimba Formation and water is rarely present in the bauxite.*

5.2.3 Potentiometric Surface, Recharge, Flow and Discharge

Seasonal rainfall and surface water flow infiltrate the ground surface and rapidly flow through the unsaturated bauxite to recharge the groundwater table, which is typically located in the weathered Bulimba Formation. Recharge through the bauxite is rapid due to efficient vertical infiltration via primary and secondary permeability and porosity. Thus, most of the flow within the bauxite is downward drainage. This is evidenced by the high vertical hydraulic conductivity and the rapid recession of the groundwater level in the bauxite, which is almost synchronous with groundwater level changes in the underlying weathered Bulimba Formation.

The groundwater table is typically located below the base of the bauxite, although limited lateral flow may occur within the bauxite during the ephemeral saturated conditions.

Discharge from the bauxite occurs via evaporation, transpiration, and downward drainage into the underlying weathered Bulimba Formation.

5.2.4 Groundwater Quality

Groundwater quality in the bauxite is non-saline (electrical conductivity (EC) of 29.7 µS/cm) and slightly acidic (in-situ pH value of 5.37). All of the major ions in solution are near or below the detection level of 1 mg/L, except sodium and chloride, both of which had a concentration of 4 mg/L. These groundwater quality characteristics reflect the fact that rainfall infiltration is the primary source of seasonal groundwater in the bauxite.

As expected, the quality of groundwater in the bauxite is very similar to that of groundwater within the weathered Bulimba Formation due to the strong hydraulic connection between these formations. This is a highly connected system, where the transient groundwater present in the bauxite, derived directly from rainfall recharge, moves quickly into the underlying weathered Bulimba Formation and thus has essentially the same water quality.

The bauxite groundwater quality is also very similar to local surface water quality (as reported in the EIS Baseline Surface Water Quality Report). This is expected because both shallow groundwater in the bauxite and surface water flows are predominantly derived from recent rainfall infiltration/runoff.

5.2.5 Groundwater Use

The bauxite is a thin surficial layer and is rarely saturated. Thus, it is not practical to obtain a reliable groundwater supply from the bauxite in the Mine Site and surrounds. There are no known groundwater users targeting the bauxite within 5 km of the Mine Site.

5.3 Weathered Bulimba Formation

5.3.1 Groundwater Distribution

The weathered Bulimba Formation is present across the entire Mine Site. It underlies the bauxite ore wherever bauxite ore is present. The weathered Bulimba Formation is up to approximately 30 m thick in the elevated parts of the Mine Site and is thinner (approximately 7 m thick) in the lower lying creeks (Figure 20). The weathered Bulimba Formation is approximately between 7 m and 27 m thick in the open cut mining areas.

The seasonally oscillating groundwater table typically resides within the weathered Bulimba Formation. During the dry season the groundwater table declines and the groundwater table is located at or near the base of this formation. The saturated thickness of the weathered Bulimba Formation during dry season conditions is approximately 5 m on average (Figure 21). In localised areas the groundwater table may fall below the base of the weathered Bulimba Formation and the weathered Bulimba Formation becomes unsaturated (Figure 21).

After recharge from wet season rainfall, the water table rises through the weathered zone. This formation can become saturated to its full thickness in the peak of the wet conditions (Figure 22). An equilibrium in the recharge and discharge mechanisms is observed through the consistent seasonal minima and maxima of the groundwater levels.

5.3.2 Hydraulic Parameters

The hydraulic conductivity of the weathered Bulimba Formation is well understood from numerous regional studies. The hydraulic conductivity ranges of the weathered Bulimba Formation derived from various regional sources are compiled in Table 2 and range from 0.007 to 63 m/d.

Site-specific permeability results collected from the Mine Site are also provided in Table 2. The measured permeability at the Mine Site ranges from 0.001 m/d to 6.8 m/d, and is generally within or comparable to the regional data.

Permeability of the weathered Bulimba Formation spans several orders of magnitude, from low to high permeability. This is a common and expected occurrence due to natural variability in sediments and weathered rock materials. The lithology of weathered rock occurring at the screen zone of the monitoring bores ranges from clay to silty clay and sandy clay (Figure 12). The higher permeability values were recorded within fine-grained materials and in the presence of macropores that enhance the hydraulic conductivity.

As with the bauxite, the measured hydraulic conductivity in the weathered Bulimba Formation can be influenced by the test method. The highest recorded ranges are from methods that test the weathered Bulimba Formation in excavated trenches and large scale tests. The results obtained from tests conducted on bores are likely to underpredict permeability, as fewer macropores are intersected.

In addition, the location of the testing will also influence the measured result. At Weipa, a well-developed sandy lithofacies occurs in the weathered zone, which has a relatively high permeability and forms a productive aquifer system. Sandy lithologies are not common within the weathered Bulimba Formation at the Mine Site, which may contribute to the comparatively low permeability measurements from the Mine Site (Table 2).

Table 2 Ranges of weathered Bulimba Formation hydraulic conductivity

Hydraulic Conductivity range (m/d)	Data Source	Site of test	Location of formation tested	Reference
0.002 – 6.8	Falling head tests	borehole	Aurukun	This study
0.001 – 0.004	Rising head tests	borehole	Aurukun	This study
0.01 – 0.15	Falling/rising head tests	borehole	Bauxite Hills	AGE, 2011
0.3 – 0.8	Falling/rising head tests	borehole	Pisolite Hills	AGE, 2010
0.007 – 1.9*	Falling head tests	borehole	Amrun	RTA Weipa & Rio Tinto Alcan, 2011
14 – 62*	Rising head tests	trenches	Weipa	Crees and Volker, 1992a
3.8 – 63*	Pumping tests	multiple boreholes	Bauxite Hills/ Skardon River	Rockwater, 1994; Golder, 1998

Note: ** Tests applied to bores screened across formations, and potentially inclusive of bauxite layer.*

5.3.3 Potentiometric Surface, Recharge, Flow and Discharge

The seasonal minima and maxima of the groundwater levels recorded in the monitoring bores is summarised in Table 3. As discussed previously, the groundwater table typically remains within the weathered Bulimba Formation and below the base of the bauxite. This is evidenced by the bores which are installed within the bauxite being dry most of the time (Table 3).

The groundwater table elevation increase in the months between January and April indicates rapid recharge related to rainfall intensity, followed by a more gentle groundwater level decline during the dry season. This indicates the vertical hydraulic conductivity in the unsaturated bauxite is high, but the horizontal conductivity of the weathered Bulimba Formation is lower, resulting in fast infiltration after rain, but slower lateral drainage over the dry season. The groundwater table elevation also shows short-lived peaks that occur after rainfall, and rapid declines that occur during periods of no rain within the wet-season. This means that rainfall recharge, when it occurs, is fast, and groundwater mounding from recharge dissipates within weeks of rainfall ceasing.

The rapid recharge also limits the potential for evaporitic concentration of salts, leading to very low salinity groundwater as discussed in Section 5.3.4.

In cross-section (Figure 14), wet and dry season groundwater levels indicate the interaction of local and regional flow patterns. The groundwater levels associated with the weathered and the fresh Bulimba Formations are integrated in Figure 14 because the upper part of the fresh Bulimba Formation is hydraulically connected to the shallow lateritic aquifer.

The groundwater elevations for both seasons (Figure 23 and Figure 24) indicate very similar flow patterns all year round, despite groundwater level fluctuations. The regional groundwater flow direction is from the higher topographic areas (mostly the northeast) to the lower lying areas in the southwest. This pattern is consistent with the regional setting, as it reflects the surface drainage. Localised topographic undulations can create short groundwater flow paths that do not conform to the regional flow direction. However, in general the water table is a subdued reflection of the topography. Baseflow is a dominant discharge mechanism as shown by the regional water table intersecting the incised creeks in the cross sections (Figure 14).

The groundwater levels in the weathered Bulimba Formation and the overlying bauxite (when saturated) are almost identical, meaning that the hydrostratigraphic units are highly connected. Vertical hydraulic gradients are expected to change over time depending on the seasons, and if the groundwater system is experiencing recharge or discharge during the wet and dry seasons, respectively.

Horizontal hydraulic gradients are typically between approximately 1:150 and 1:210. These values indicate that relatively steep gradients are present. The steepest hydraulic gradients are present near creek lines and the gentlest gradients are in elevated areas (Figure 23 and Figure 24). There is little seasonal variability in the horizontal hydraulic gradient.

5.3.3.1 Recharge

Diffuse rainfall recharge occurs ubiquitously in the Mine Site. The wet-season and dry-season depth to water maps are shown in Figure 15 and Figure 16, respectively.

The maps show a water table fluctuation in the elevated areas of approximately 10 m (e.g. at bore C_MB6A); whereas at lower elevations this fluctuation is approximately 5 m or less (e.g. bore C_MB8A). The data indicates higher recharge rates in elevated areas, compared to lower lying areas. For bore C_MB6A, 915 mm of rain over a 14-day period in January/February 2018 resulted in a 10.5 m water level change. In contrast, down-gradient bore C_MB9A recorded a water level rise of 6.55 m following the same period of rainfall.

Recharge rates were estimated using groundwater table fluctuation and chloride mass balance methods. These methods confirm that high recharge rates occur across the Mine Site, with recharge in elevated areas being greater than recharge in lower lying areas. The high recharge rates are consistent with the tropical climate with intense seasonal rainfall, permeable soils, enhanced vertical hydraulic conductivity (macropores) and gentle to intermediate topographic slopes. In addition to the climatic and topographic influence on recharge rates, the high permeability of the bauxite acts to enhance infiltration of rainfall into the unsaturated zone, thereby increasing the percentage of rainfall that becomes groundwater recharge. This process of rapid vertical seepage in the unsaturated zone also diminishes evaporation.

5.3.3.2 Discharge

Groundwater discharge from the weathered Bulimba Formation predominantly occurs via:

- Lateral flow to creeks and surface water features where groundwater seepage provides baseflow;
- Evaporation from areas where the groundwater table is close to the surface; and
- Transpiration from woodland vegetation.

The last two processes are termed evapotranspiration when considered jointly. Discharge also occurs, to a lesser extent, through lateral flow to adjacent formations, and coastal discharge.

As noted in Section 5.3.3, the recession of the groundwater table in the dry season occurs more slowly than the preceding wet season groundwater level rise. This indicates that the discharge mechanism is a slower rate than recharge. Over time, the slower rate of discharge is accommodated in the system, as the longer dry season allows for dissipation of the accumulated recharge volumes. As such, the system is in a state of near equilibrium, where water levels return to a similar peaks and lows each season. The seasonal minima of the water table varies each year due to the specific rain patterns of that season.

Based on the high evapotranspiration rates, and the dense vegetation cover dominated by mature trees, evapotranspiration is an important mechanism for removal of groundwater from the weathered Bulimba Formation. During the dry season, water table levels sit deeper in the profile, sometimes exceeding 20 m, and are expected to fall below the root depth of the dominant vegetation in some areas. The depth of the water table below the ground surface is therefore a limiting factor for evapotranspiration, as tree roots cannot access the water table for transpiration when water levels are too deep.

Lateral discharge of groundwater from the weathered Bulimba Formation occurs via horizontal flow toward the coastline. The groundwater flow direction mimics that of the surface drainage features, from northeast to southwest; therefore, groundwater output through the cross-sectional area of the southwestern or western margins could be considered discharge from the site. The volume of this discharge is proportional to the saturated thickness of the aquifer, but also the hydraulic gradient and the hydraulic conductivity of the unit, both of which are known to be variable.

Groundwater discharge also occurs via baseflow to the creeks that are incised below the level of the groundwater table at the Mine Site. The cross sections (Figure 14) and depth to water maps (Figure 15 and Figure 16) demonstrate that groundwater levels near creeks can be at or very close to the ground surface, especially during the wet season. In addition, the incision of the drainage lines creates topographic lows where the groundwater table will intersect the land surface more easily. The weathered Bulimba Formation is the main geological formation in direct contact with the drainage lines of the Mine Site (as shown in Figure 8 and Figure 14), hence groundwater seepage from the weathered Bulimba Formation is an important discharge mechanism for this formation, and provides baseflow to the creeks traversing the Mine Site and its surrounds.

The creeks at the Mine Site are ephemeral, with some remnant pools that persist into the dry season. These remnant pools are sustained by baseflow from groundwater seepage. Baseflow from groundwater seepage is predominantly a wet-season and post-wet-season groundwater discharge mechanism.

Table 3 Bore groundwater level minima and maxima for November 2017 to November 2018

Bore ID	TOC (mAHD)	Screen to (mBGL)	Screen from (mBGL)	Screen top (mAHD)	Screen bottom (mAHD)	Dry season depth to water (mBTOC)	Wet season depth to water (mBTOC)	Dry season groundwater level (mAHD)	Wet season groundwater level (mAHD)	Base of Bauxite (mAHD)
C_MB1A	57.264	24.7	30.7	31.5	25.5	dry	5.58	dry at 40.6	51.69	53.25
C_MB2A	35.831	17	20	18.0	15.0	18.97	13.12	16.86	22.71	28.98
C_MB3A	43.904	21	24	22.0	19.0	13.80	3.45	30.1	40.45	39.00
C_MB4A	50.489	18	21	31.6	28.6	19.29	7.97	31.2	42.52	46.61
C_MB5A	70.73	14	17	56.1	53.1	Dry	7.79	dry at 52.6	62.94	68.11
C_MB6A	84.144	20.5	23.5	62.7	59.7	16.74	5.94	67.4	78.20	80.17
C_MB7A	68.029	24.5	27.5	42.9	39.9	11.33	5.14	56.7	62.89	62.36
C_MB8A	39.423	17.8	20.8	20.7	17.7	Dry	14.02	dry at 21.0	25.40	33.50
C_MB9A	35.87	21	24	13.9	10.9	18.97	12.35	16.9	23.52	28.93
C_MB10A	72.815	17	21	54.8	50.8	16.62	6.07	56.2	66.75	67.80
C_MB11A	49.876	30	33	19.1	16.1	dry	23.48	dry at 24.86	26.40	45.07

Notes: *mAHD – metres Australian Height Datum.*

TOC – top of casing.

mBGL – metres below ground level.

mBTOC – metres below t op of casing.

5.3.4 Groundwater Quality

Groundwater in the weathered Bulimba Formation is characterised by low salinity, with median EC values for each bore ranging from 26 µS/cm to 350 µS/cm (Figure 25). The lower EC value is representative of the typical solute concentration expected in rainfall recharge. This reinforces the understanding that recharge processes are rapid, and evaporation (causing evaporitic concentration of solutes) is not pervasively dominating the system. The higher groundwater EC values at some bores denote a greater solute load, reflecting the process of accumulation of solutes through water-rock interaction, and a small degree of evaporitic concentration. Although noted as having relatively higher EC, these samples are still fresh water, being about a third of the salinity limit for potable water (1,000 µS/cm). Thus, intense evaporative concentration of solutes is not observed. This is due to effective flushing of the groundwater system each wet season with high rainfall.

Median groundwater pH values for each bore range from 4.93 to 8.63 (Figure 25). On balance, the groundwater is slightly acidic. This is due to the interaction of fresh recharge water (rainfall) with soil CO_2. This reaction produces carbonic acid in the "young" groundwater. As the dissolved acid is consumed through water-rock interaction, solutes are added to solution, and the pH increases to neutral levels.

The groundwater major ion composition is variable and includes mainly $Na\text{-}HCO_3$-type water, with some $Ca\text{-}HCO_3$-type and $Ca\text{-}SO_4$-type water (Figure 26). The variable composition is normal for water with so few solutes.

The dissolved metal concentrations are generally low, due to the overall low salinity of the samples. Dissolved concentrations of arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silicon, strontium, uranium, vanadium, and zinc were either below the detectible limit, or below the generic guideline values (provided for context only) at all bores. As is expected from the lateritic geological setting, the groundwater samples have dissolved aluminium, iron, and manganese in detectable concentrations.

Hydrocarbons (TPH, TRH and BTEX) and nutrients (nitrogen and phosphorous species) are generally not present in groundwater in the weathered Bulimba Formation. This is expected given there is no agricultural or industrial land use in the area.

5.3.5 Groundwater Use

There are no known groundwater users within 5 km of the Mine Site.

5.4 Fresh Bulimba Formation

5.4.1 Groundwater Distribution

The fresh Bulimba Formation is completely overlain by the weathered Bulimba Formation within the Mine Site. The depth of the fresh Bulimba Formation is shown in Figure 27.

The fresh Bulimba Formation is essentially completely saturated as the groundwater table predominantly occurs within the overlying weathered Bulimba Formation. In highly localised areas, the upper profile of the fresh Bulimba Formation can become unsaturated during the dry season when the groundwater table is at its lowest elevation.

The distribution of groundwater pressure (head) in the fresh Bulimba Formation in the wet (Figure 28) and dry (Figure 29) seasons mimics the gradients of the groundwater table in the respective seasons.

5.4.2 Hydraulic Parameters

The hydraulic conductivity ranges of the fresh Bulimba Formation are shown in Table 4. The range from all viable tests undertaken at the Mine Site is between 0.001 m/d to 0.06 m/d. The two methods applied in this study (falling head test from in-situ permeability testing and rising head tests from recovery) provided consistent results for hydraulic conductivity (Figure 12). In addition, these site measurements compare well to other regional estimates for this unit (Table 4). The data are well constrained within a range of one or two orders of magnitude.

The fresh Bulimba Formation is less permeable and less variable in its permeability than the weathered Bulimba Formation (Figure 12) due to the following interrelated factors:

- the lithology of the fresh formation, which is typically a consolidated siltstone, is naturally less permeable than unconsolidated sediments;
- the secondary porosity (i.e. macropores) of the fresh formation is expected to be minimal, as there is very little weathering in this permanently saturated zone;
- the lower abundance of clay minerals and the lack of intermittent drying in the fresh Bulimba Formation means that there is negligible clay cracking contributing to macropores; and
- the small scale tests of the fresh Bulimba Formation are accurate, due to the absence of larger secondary porosity features.

Table 4 Ranges of fresh Bulimba Formation hydraulic conductivity

Hydraulic Conductivity range (m/d)	Data Source	Scale of test	Location of formation tested	Reference
0.005 – 0.06	Falling head tests	borehole	Aurukun	This study
0.001 – 0.01	Rising head tests	borehole	Aurukun	This study
0.01 – 0.15	Falling/rising head tests	borehole	Bauxite Hills	AGE, 2011
0.002 – 0.01	Falling/rising head tests	borehole	Pisolite Hills	AGE, 2010

5.4.3 Potentiometric Surface, Recharge, Flow and Discharge

The distributions of groundwater pressure in the fresh Bulimba Formation in the wet and dry seasons are shown in Figure 28, and Figure 29, respectively. The groundwater level data from both the weathered and fresh Bulimba Formation bores were integrated as the vertical gradients are shown to be negligible. Therefore, the depth to water level maps (Figure 15 and Figure 16) and cross sections (Figure 14) presented in Section 5.1 are also relevant to discussions of groundwater flow in the fresh Bulimba Formation.

The flow system of the fresh Bulimba Formation is highly connected to the weathered Bulimba Formation and all flow directions are the same. This connection is expected to reduce with depth as layering of fine grained lithologies within the fresh Bulimba Formation reduces the effective vertical hydraulic conductivity with depth.

The main difference between these units is that the fresh Bulimba Formation is expected to be effectively ubiquitously and permanently saturated, whereas the water table resides and oscillates within the overlying weathered formation. As such, all groundwater recharged to the fresh Bulimba Formation is via the overlying weathered unit.

Discharge from the fresh Bulimba Formation is via upward flow driven by local or regional gradients into the weathered Bulimba Formation (Section 5.3.3). The preferred groundwater flow path through the fresh Bulimba Formation is lateral, due to the low permeability of the underlying units and the influence of the groundwater discharge zones. There is negligible downward groundwater flow from the fresh Bulimba Formation into underlying units.

5.4.4 Groundwater Quality

Groundwater quality in the fresh Bulimba Formation is essentially indistinguishable from groundwater in the weathered Bulimba Formation because there is a high degree of hydraulic connection between the two formations, and also because groundwater residence times are relatively short, preventing strong water-rock interaction signatures from developing. This means that groundwater from the fresh Bulimba Formation is characterised by:

- low salinity;
- typically slightly acidic to neutral pH;
- concentrations of arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silicon, strontium, uranium, vanadium, and zinc below the detectible limit or below the generic guideline values (provided for context only);
- detectable concentrations aluminium, iron, and manganese due to natural dissolution in the lateritic geology; and
- negligible hydrocarbons and nutrients.

5.4.5 Groundwater Use

There are no known groundwater users within 5 km of the Mine Site.

6 Impact assessment

This section provides a detailed assessment of the predicted effects of the project on groundwater levels and quality, and the potential impacts of these effects on groundwater users and sensitive environmental features. This section is structured as follows:

- Sections 6.1 and 6.2 detail the project mining operations as they relate to the groundwater assessment, and the associated effects on the groundwater regime;
- Section 6.3 provides the groundwater model results;
- Section 6.4 explains how groundwater resources, groundwater users, or sensitive environmental features may be impacted by the changes in groundwater levels;
- Section 6.5 describes the potential cumulative impacts; and
- Section 6.6 summarises the potential impacts to groundwater quality.

6.1 Overview of Mining

The project involves the development of open cut mining areas within the Mine Site. The open cut mining areas and their extents are shown in Figure 2. The open cut mining methods are described in Section 1.

Mining targets the bauxite ore. The bauxite ore is overlain by thin soils. The depth of cover (above the bauxite ore) in the open cut mining areas is variable, but is typically in the order of 1 m. The bauxite ore thickness is also variable, ranging from approximately 2 m to 13 m thick in the open cut mining areas. The depth of open cut mining ranges up to approximately 14 m below ground level.

Mining would not extend into the weathered Bulimba Formation that underlies the bauxite ore and would not intersect any of the underlying formations.

Conceptually, mining would initially commence in Project Year 1 in the open cut mining area located in the north-west of the Mine Site. This open cut mining area would expand over several years as mining progresses in this area. The development of open cut mining areas located in the centre of the Mine Site (south east of Coconut Creek) would commence several years later. Several open cut mining areas would then be mined concurrently for the remainder of the 22 year mine life.

Initially, soils removed from the surface of the mining areas would be stored in out-of-pit stockpiles situated adjacent to the open cut mining areas. As the open cut mining areas develop, soils would be reused for capping and rehabilitation. The project involves limited clearing and ground disturbance outside the open cut mining areas. The open cut mining areas and other disturbed areas would be rehabilitated progressively as the mine develops. The rehabilitation of cleared and disturbed areas is expected to occur progressively following cessation of mining.

The process of screening and washing bauxite at the Beneficiation Plant would produce product bauxite and fines. Fines would be stored in an out-of-pit Fines Containment Area (FCA) (Figure 2) during the first three years of operations, and thereafter in dedicated in-pit fines backfill areas. The FCA would be decommissioned after Project Year 3. The in-pit fines backfill areas would be designated areas where mining activity has been completed. The operation of the FCA and in-pit fines backfill areas is described in the EIS Fines Emplacement Conceptual Design Report.

The final landform is described in the Progressive Rehabilitation and Closure Plan (PRC Plan) included in the EIS. The PRC Plan concludes that the final landform is free-draining and would not result in significant changes to the existing catchment boundaries of Tapplebang Creek, Coconut Creek, or the Ward River.

Product bauxite would be transported to the Coastal Loading Facility (CLF) via the Product Bauxite Transport Corridor (Figure 2). The product bauxite may be stockpiled at the CLF prior to being loaded onto a Transhipment Vessel. No open cut mining would be undertaken within the Product Bauxite Transport Corridor.

It would also be necessary to construct a dam on Tapplebang Creek (called Tapplebang Dam) (Figure 2). Tapplebang Dam is a valley-fill dam that would collect and store surface water from Tapplebang Creek for use as a water supply for mining operations and for the later stages of construction. The dam embankment would include a spillway and dedicated fish passage.

The dam embankment would be up to 19 m high with a footprint covering an area of 5.3 ha. The dam would have a storage capacity of approximately 10.5 GL. The contributing catchment of the dam is approximately 110 km^2. The dam would be commissioned in Project Year -1 and allowed to fill. A dam lake would form upstream of the dam embankment and would inundate an area of up to 247 ha when the dam is full. During mining operations, groundwater interactions with surface water in the Tapplebang Dam lake (including the reach of Tapplebang Creek within the dam lake inundation footprint) would be determined by the operation of Tapplebang Dam. The operation of Tapplebang Dam is described in the EIS Mine Water Balance Modelling Report. The dam embankment would be decommissioned at the end of the mine life. The dam decommissioning process is described in the EIS Mine Rehabilitation and Closure Section.

6.2 Mining Effects on Groundwater

The process of open cut mining typically reduces groundwater pressures (and levels) in the geological units surrounding the mining excavation. The affected area is referred to as the zone of depressurisation or drawdown.

However, these effects are negligible when mining is above the groundwater table. Further, they may be completely or partially offset by the infiltration of rainfall and stored pit water in the open cut mining areas. Rainfall and pit water infiltration recharges the groundwater regime and increases groundwater levels in the surrounding areas. In addition, vegetation clearing in the open cut mining areas can reduce the natural groundwater discharge via transpiration, which increases groundwater levels in the cleared open cut mining areas. If groundwater recharge and reduced transpiration exceed the effects of depressurisation, there will be a net increase in groundwater pressure and level. This is also called groundwater ‘mounding’.

The extent and magnitude of depressurisation or mounding depends in part on the properties of the ore and other strata (including fines). The magnitude of the pressure reduction/increase is also influenced by distance from mining activities, with the greatest changes occurring adjacent to the open cut pits and key mine infrastructure and gradually reducing with distance from these areas.

The mining sequence and mine plan will dictate the occurrence (extent and magnitude) of groundwater depressurisation/mounding at each stage of the mine development. The mine schedule will result in some open cut mining areas being completed (i.e. mined and/or backfilled) while other open cut mining areas are still active or have not yet been developed. Groundwater recovery will therefore commence in the completed open cut mining areas (e.g. those mining areas developed early in the mine life) while mining activities are ongoing in other areas (i.e. those mining areas developed late in the mine life). This sequencing has been captured in the groundwater modelling.

In summary, the key effects on the groundwater regime that could arise directly from the proposed mining operations and the operation of mine infrastructure are expected to include:

- Changes to groundwater levels due to:
    - Changes (decreases) in ground surface elevation in open cut mining excavations;
    - Introducing low permeability fines in the in-pit backfill areas, raising the ground surface elevation, and changing the water storage properties in these areas;
    - Enhancing groundwater recharge in the vicinity of the open cut mining areas, in-pit fines backfill areas, and the FCA, which would increase groundwater levels in the geological formations surrounding the mining excavations and the FCA;
    - Decreasing the rates of transpiration (and groundwater discharge) in the vegetation clearing footprint, which would increase groundwater levels in the underlying geological formations;
- Changes to the groundwater quality due to:
    - Seepage from the open cut mining areas;
    - Seepage from the operation of the FCA and in-pit fines backfill areas; and
    - The use of hydrocarbons and chemicals.

Section 6.3 describes the predicted changes to groundwater levels due to the project. The associated impacts on groundwater users and the surrounding environment are described in Sections 6.4 and 6.5.

Section 6.6 describes the expected groundwater quality effects and associated impacts.

6.3 Predicted Groundwater Levels

A 3D numerical groundwater flow model was developed to predict the effects of the project on groundwater levels. Appendix D provides a detailed technical description of the model development, construction, calibration, predictions, and sensitivity analysis.

Typically, assessments focus on the zone of depressurisation or mounding at the end of mining operations, as this represents the cessation of mine dewatering and this scenario typically represents the maximum extent and/or magnitude of depressurisation associated with open cut mining. However, as discussed in Section 5, the groundwater regime in the vicinity of the project site experiences significant and rapid seasonal changes in groundwater levels that could mask the effects of early mining on the groundwater regime. Hence, it is not meaningful or conservative to only assess the depressurisation or mounding at the end of mining operations.

To ensure that the worst-case impacts on groundwater users and sensitive environmental features are assessed, the zone of depressurisation/mounding has been assessed using figures showing the maximum zone of depressurisation/mounding for two periods: a) overall life of mine, and b) post mining equilibrium. Figure 30 shows the maximum predicted zone of depressurisation and mounding due to the project during the life of the mine (i.e. to the end of Project Year 22). Figure 31 shows the maximum predicted zone of depressurisation and mounding that occurs over the long-term equilibrium in the post mining phase (i.e. from 66 years to 76 years after Project Year 22). It should be emphasised that the depressurisation and mounding shown in Figure 30 and Figure 31 do not occur at a single point in time, but rather they show the maximum of all aggregated model predictions over the life of mine period and post mining equilibrium period, respectively.

These results are presented in terms of the change in the local groundwater table, which is typically hosted in the weathered Bulimba Formation, and seasonally within the overlying bauxite (or very rarely in the fresh Bulimba Formation). Hence, it is not meaningful to present these results for individual formations.

For the purposes of the groundwater assessment undertaken for the project, the limit of the zone of depressurisation/mounding is conservatively defined by a predicted change in the groundwater table elevation by more than 1 m. A 1 m change in the groundwater table elevation was adopted in defining the limit of the zone of depressurisation/mounding as it is well within the range of natural groundwater level fluctuations between wet and dry seasons and also represents the reasonable limit of precision that can be inferred from groundwater modelling.

In addition, the groundwater model was used to provide hydrographs showing the change in groundwater levels and groundwater seepage (as baseflow) at six intervals per year during the mining operations and post mining. The hydrographs show model results for existing conditions and with development of the project. The hydrograph sites are shown in Figure 32. The following hydrographs were produced:

- 24 hydrographs (Appendix F, Figures F2 to F25) showing the predicted groundwater levels at locations around the open cut mining areas and mine infrastructure. These hydrograph sites are located within areas of riparian and woodland vegetation throughout the Mine Site.
- 26 hydrographs (Appendix E, Figures E2 to E27) showing the predicted groundwater levels at locations AQ1 to AQ26, which represent areas of aquatic habitat along the lengths of Coconut Creek and Tapplebang Creek, including areas where seasonal groundwater seeps and wetlands were observed by the EIS aquatic ecologist.
- Four hydrographs (Figure 33 to Figure 36) showing the predicted changes to groundwater seepage (baseflow) in Coconut Creek, Tapplebang Creek, the Ward River, and the Norman Creek tributary.
- Six hydrographs (Figure 37 to Figure 42) showing the predicted changes to groundwater seepage (baseflow) in individual reaches of Coconut Creek and Tapplebang Creek.

Sections 6.3.1 to 6.3.4 provide a detailed description of the groundwater level and baseflow predictions. Groundwater take is discussed in Section 6.3.5.

6.3.1 Maximum Predicted Drawdown and Mounding During Mining Operations

Figure 30 shows that localised drawdown and mounding of the groundwater table are predicted around the proposed open cut mining areas, in-pit fines backfill areas, the FCA, and Tapplebang Dam.

Drawdown is predicted to be greatest in the open cut mining areas, where the open cut mining activities are expected to intersect the groundwater table following the wet season recharge, when the groundwater table it is at its shallowest. The groundwater table is predicted to experience up to approximately 8 m of drawdown within the open cut mining areas. Outside the project disturbance footprint, the maximum predicted drawdown is up to approximately 3 m.

The zone of depressurisation is predicted to extend up to 600 m from the project disturbance footprint and generally remains localised within the Mine Site. The furthest extent of the zone of depressurisation outside the boundary of the Mine Site is on the western side, and is less than 600 m.

Drawdown does not extend to the deeper layers of the Rolling Downs Group or the formations of the GAB due to the significant thickness (up to approximately 1 km) of low permeability siltstone and claystone between these formations. The Rolling Downs Group and deeper formations of the GAB are not predicted to be depressurised by the project.

Mounding is predicted to be greatest in the open cut mining areas, in-pit fines backfill areas, FCA, and adjacent to the Tapplebang Dam wall. The groundwater table is predicted to experience up to approximately 16 m of mounding within these areas. The predicted mounding is due to: a combination of reduced transpiration due to vegetation clearing; enhanced groundwater recharge from infiltration of rainfall and entrained fines water; low water storage capacity in deposited fines; and raised ground surface levels in the FCA and in-pit fines backfill areas compared to the natural pre-mining ground surface.

The zone of mounding is predicted to extend up to approximately 1,800 m from the project disturbance footprint and generally remains localised within the Mine Site. The furthest extent of the zone of mounding outside the boundary of the Mine Site is on the western side, and is less than 1,400 m.

Figure 30 shows temporary mounding of groundwater levels within and around the dam lake. It should be noted that the mounding within the dam inundation footprint represents the simulated groundwater level below the dam. In reality, the groundwater levels in and around Tapplebang Dam will be dictated by the operation of the dam and the surface water level in the dam lake. The operation of Tapplebang Dam is described in the EIS Mine Water Balance Modelling Report.

Figure 30 also shows that there is considerable overlap between the predicted areas for drawdown and those for mounding. As these processes cannot be synchronous, this overlap signifies that drawdown and mounding will occur at different times.

The potential impacts of groundwater drawdown and mounding on existing groundwater users and sensitive environmental features are discussed in Sections 6.4 to 6.5.

6.3.2 Maximum Predicted Post Mining Drawdown and Mounding

Predictive modelling was undertaken to simulate post mining groundwater levels. This simulation period comprised the period following the end of mining operations when vegetation establishes in rehabilitated areas, and the subsequent period of post closure conditions to the post mining equilibrium.

Figure 31 shows that localised drawdown and mounding of the groundwater table are predicted around the proposed open cut mining areas and in-pit fines backfill areas. Figure 31 shows that localised mounding is predicted beneath the FCA.

The drawdown extents are comparable to those predicted during mining operations. Drawdown is predicted in areas where the final landform ground surface elevation is lower than the natural ground surface elevation (i.e. rehabilitated open cut mining excavations). In these areas, the elevation of transpiration is simulated to be lower, resulting in drawdown.

The mounding extents are significantly smaller when compared to those predicted during mining operations.

The maximum predicted long-term changes in post mining groundwater level are summarised as follows:

- The groundwater table is predicted to experience up to approximately 9 m of drawdown within the open cut mining areas. Outside the project disturbance footprint, the maximum predicted drawdown is up to approximately 2 m.
- Drawdown does not extend to the underlying Rolling Downs Group or deeper formations of the GAB.

- Mounding is predicted to be greatest in the in-pit fines backfill areas and the decommissioned FCA due to backfilling and soil cover raising the ground surface elevation compared to the natural pre-mining ground surface. The groundwater table in these areas, therefore, will re-stablish at a higher elevation than natural pre-mining groundwater table. The groundwater table is predicted to experience up to approximately 7 m of mounding within these areas.
- As expected, there is no long-term post mining mounding of groundwater levels within and around the decommissioned Tapplebang Dam.
- Similar to the mining operations phase, there is overlap between the predicted areas for drawdown and those for mounding, indicating that drawdown and mounding will occur at different times post mining.

The potential impacts of groundwater drawdown and mounding on existing groundwater users and sensitive environmental features are discussed in Sections 6.4 to 6.5.

6.3.3 Predicted Hydrographs in Open Cut Mining Areas

Hydrographs for sites surrounding the open cut mining areas and mine infrastructure (i.e. Appendix F, Figures F2 to F25) provide additional information on the predicted temporal changes in groundwater levels. These hydrographs confirm that:

- Seasonal fluctuations in groundwater levels within the in-pit fines backfill areas are predicted to increase due to the hydraulic properties of the fines.
- Mounding of water levels generally occurs during mining operations, and while vegetation is regenerating in the 10 to 15 years post mining. Mounding is temporary and is more prevalent when the groundwater table is low, following the dry season.
- Negligible post mining change in groundwater levels is predicted in the majority of hydrograph sites surrounding the open cut mining areas and mine infrastructure.
- Post mining drawdown is most prevalent around completed mining areas, where drawdown is less than approximately 2 m.

6.3.4 Predicted Effects on Watercourses and Drainage Features

A small increase (approximately 7% on average) in total baseflow from groundwater seepage is predicted in Coconut Creek and Tapplebang Creek during mining operations. This is due to the combined effect of increased rainfall recharge and lower transpiration due to vegetation clearing, the operation of Tapplebang Dam, and seepage from mining pits, in-pit fines backfill areas, and the FCA into the groundwater table. This represents a minor change in the contribution from groundwater baseflow to the natural flow regime of these watercourses, which is insignificant when compared to the year-to-year variations in surface water flow in these creeks.

The small increase in baseflow is predicted to dissipate following the cessation of mining operations. This is due to increased transpiration as vegetation becomes established in rehabilitated areas and reduced seepage due to the decommissioning of Tapplebang Dam.Figure 33, Figure 34, and Figure 36 show that a minor reduction in the long-term post mining baseflow is predicted in Coconut Creek, Tapplebang Creek, and the catchment of Norman Creek upstream of Arraw Dam. The predicted decrease in baseflow is approximately 4% in Tapplebang Creek, approximately 3% in Coconut Creek, and approximately 0.6% in the Norman Creek catchment. The predicted change in baseflow is not expected to have a measurable effect on the natural flow regime in these creeks and is expected to be indistinguishable within the context of the significant natural year-to-year variations in total water flow in these creeks.

The project is not predicted to result in any significant change in groundwater seepage as baseflow during the post mining phase, once the groundwater system has reached an equilibrium. Figure 35 shows that there is no long-term post mining reduction in baseflow in the Ward River.

It should also be recognised that there are reasonable limits to the accuracy of predictions of changes in baseflow from large numerical groundwater models. The predicted minor changes to baseflow of less than 4% are beyond the reasonable limit of accuracy of such a model. As discussed in Section 7, a comprehensive groundwater monitoring program will be implemented to identify and investigate any departures from the model predictions. In addition, the EIS Surface Water Section describes the surface water flow monitoring program that has been established to characterise natural baseflow conditions in these creeks and identify any measurable changes in baseflow due to mining.

It should also be noted that the model predictions of minor reductions in baseflow are based on the following key assumptions:

- The assumption that the rooting depth of vegetation established in the rehabilitated areas post mining returns to the same depth as pre-mining vegetation. This means that in the rehabilitated areas where the ground surface is lowered due to mining, the rooting depth would be at a lower elevation post mining. Hence, this assumption has the effect of lowering the post mining groundwater table, contributing to the predicted reduction of baseflow. In reality, the rooting depths of vegetation may be shallower due to the shallower depth of the groundwater table, and as such the assessment of post mining baseflow presented above is conservative.
- The worst-case assumption that Tapplebang Dam will be decommissioned or removed post mining. If Tapplebang Dam were to be retained post mining, this would result in mounding of groundwater levels in the vicinity of the dam lake. Mounding of the groundwater table in the vicinity of Tapplebang Dam during the post mining equilibrium would increase baseflow in Tapplebang Creek (as observed during mining operations, discussed below), resulting in no net decrease in Tapplebang Creek baseflow. Hence, the assessment of post mining baseflow presented above is conservative.

The aquatic habitats areas (AQ1 to AQ26) identified in the EIS Aquatic Ecology Report are shown in Figure 32. The predicted groundwater level and baseflow effects at the aquatic habitat locations are as follows:

- Figures E2 to E9 and Figure 37 show that no change to groundwater levels or seepage as baseflow is predicted for the upper reaches of Coconut Creek (i.e. upstream of AQ8).
- Figures E13 and E16 and Figure 38 to Figure 40 show that the mid-reaches of Coconut Creek at AQ10 and AQ13 are predicted to experience increases in groundwater levels, and increases in groundwater seepage as baseflow at varying times throughout the life of the project. This is due to the proximity of the FCA and open cut mining areas where enhanced recharge and groundwater mounding is predicted to occur. Groundwater levels and seepage as baseflow at these locations are predicted to return to pre-mining levels following decommissioning of the FCA and cessation of mining operations.
- Figure 41 shows that negligible change to groundwater seepage as baseflow is predicted within the reaches of Coconut Creek downstream of the project site boundary.

- Figure E15 shows that a long-term post mining change in groundwater levels is predicted at the groundwater seep identified at AQ12. AQ12 is located within a small groundwater seep that flows into Coconut Creek's lower reaches. At this location, it is predicted that the maximum wet season and minimum dry season groundwater levels will be approximately 1 m lower over the long-term post mining. However, Figure E15 also shows that groundwater levels will continue to intersect the ground surface seasonally, resulting in groundwater seepage. Further, Figure 40 shows that there is no significant long-term impact on the post mining groundwater seepage rate/volume (i.e. baseflow) in the reach of Coconut Creek downstream of AQ12.
- Figures E17, E18 and E20 to E23 to show that there is no predicted change to groundwater levels within upper reaches of Tapplebang Creek.
- Figures E25 to E27 show that groundwater levels in the mid-reaches of Tapplebang Creek are dictated by the operation of the Tapplebang Dam storage during mining operations. Groundwater levels rapidly return to pre-mining levels following decommissioning of the dam.
- Figure E28 shows that a long-term post mining change in groundwater levels is predicted in the reach of Tapplebang Creek downstream of the dam. At this location, pre-mining groundwater levels are below ground level all year. The groundwater model predicts that the maximum wet season and minimum dry season groundwater levels will be approximately 1 m lower over the long-term post mining. This change in groundwater levels is due to the proximity of rehabilitated open cut mining areas, and the associated effects of the final landform on groundwater levels in the surrounding area. The change is not related to the dam. Figure E28 shows that post mining groundwater levels (near the dam wall) will continue to remain below ground level all year. This is consistent with the pre-mining conditions. Figure 34 shows that there is no significant long-term post mining change in groundwater seepage as baseflow in Tapplebang Creek once the groundwater regime has reached equilibrium.
- Figure E2 shows that there is no predicted change to groundwater levels in the vicinity of the wetland at AQ25 (known as the 'off-lease swamp').
- Figure E3 shows that a temporary change in groundwater levels is predicted in the Norman Creek tributary. At this location, pre-mining groundwater levels are below ground level all year. The groundwater model predicts that minimum dry season groundwater levels will be less than 1 m higher during three operating years. This change in groundwater levels is due to the proximity of open cut mining areas and in-pit fines backfill areas, and the resulting effects on groundwater levels in the surrounding area. Figure E3 shows that post mining groundwater levels will continue to remain below ground level all year. This is consistent with the pre-mining conditions. Figure 36 shows that there is no significant change in groundwater seepage as baseflow in the Norman Creek catchment during the post mining phase once the groundwater regime has reached equilibrium.

6.3.5 Groundwater Take

The model predicts that there will be no net take of groundwater from any aquifers because the project will result in an overall increase in groundwater recharge, and a smaller increase in groundwater discharge (as baseflow).

A discussed in Section 2, the proponent will be required to measure and report its actual groundwater take annually during the mine life in accordance with mandatory requirements of the MR Act.

In addition, any departure from the predicted groundwater take will be identified as part of the mandatory UWIR review process under the Water Act. The proponent will be obligated to investigate any departure and assess the potential for any adverse environmental impacts arising from mining activities. The findings of this review will be reported to DES annually.

6.4 Project Impacts

The predicted effects of mining on groundwater levels was used to assess the potential impacts of the project on groundwater users and the surrounding environment. Potential impacts include:

- Impacts on the regulated groundwater resources;
- Impacts on groundwater supply bores;
- Impacts on watercourses and drainage features;
- Impacts on wetlands;
- Impacts on Groundwater Dependent Ecosystems; and
- Cumulative impacts (i.e. due to operation of the project and other groundwater users) on creeks, surface water features, ecosystems, and groundwater resources and users.

Sections 6.4 to 6.5 describe potential impacts related to predicted changes in groundwater levels.

6.4.1 Impacts on Groundwater Resources

The Bulimba Formation (weathered and fresh) within the project site and its surrounds is located in the Cape York Underground Water Management Area. Groundwater take from the Cape York Underground Water Management Area is regulated under the Cape York Water Plan.

The Rolling Downs Group and the deeper formations of the Carpentaria Basin are located in the GABORA Water Plan area and groundwater take from the Rolling Downs Group is regulated under the GABORA Water Plan.

As explained in Section 6.3.5, the groundwater model predicts that there will be no net take of groundwater from the Bulimba Formation or the Rolling Downs Group due to the project. Hence, the project is not predicted to impact regulated groundwater resources.

6.4.2 Impacts on Groundwater Users

A bore census was carried out to identify water supply bores that could potentially be impacted by the project. The bore census drew upon information gathered through consultation with relevant landholders, field inspections, advice from the proponent, and a search of the DRDMW's groundwater database.

The bore census was targeted towards water supply bores that could potentially be impacted by the project due to their proximity to proposed mining activities. The local hydrogeology was also taken into account in planning the bore census. The bore census included a conservative search radius of 5 km beyond the boundary of the project site.

The bore census confirmed that there is a general lack of water supply bores in the surrounding area. This is to be expected, given the general lack of agriculture or residential/industrial development.

A single water supply bore (Beagle Camp Bore) was identified during the bore census. The registered water supply bore is located within the project site (Figure 10). While this bore is present, it has been damaged by bushfires and all bore equipment has been destroyed. Hence, the bore is in disrepair and is effectively unusable. No other water supply bores are present within the project site or its surroundings within a 4 km radius.

The Amrun Mine groundwater supply borefield is located approximately 6 km to 15 km west of the project site (Figure 10) and targets groundwater located approximately 1 km below ground level in the deep GAB aquifers of the Carpentaria Basin. The Amrun Mine groundwater supply borefield is located outside the maximum predicted extent of drawdown or mounding from the project. In addition, as discussed in Section 6.3, the project is not predicted to depressurise the deep GAB aquifers targeted by the Amrun Mine groundwater supply borefield. Hence, the Amrun Mine water supply borefield is not predicted to experience any drawdown from the project, and the operation of these bores is therefore not expected to be impaired as a result of the project.

The Aurukun town groundwater supply bores are located more than 20 km from the Mine Site boundary (Figure 10). These groundwater supply bores are located at least 19 km outside the post mining predicted extent of drawdown from the project. Hence, the town water supply bores are not predicted to experience any drawdown from the project, and the operation of these bores is therefore not expected to be impaired as a result of the project.

6.4.3 Impacts on Watercourses and Drainage Features

The project site is traversed by two main watercourses, Tapplebang Creek and Coconut Creek (Figure 32). Coconut Creek flows in a south-westerly direction joining Tapplebang Creek to become the Ward River, approximately 9 km from the project site boundary. A minor tributary of Norman Creek traverses the northern part of the project site. The project site is drained by these creeks, associated minor tributaries, and overland sheet flow.

Tapplebang Creek, Coconut Creek and the minor tributary of Norman Creek are ephemeral, with flows continuing for an extended period of time after the wet season, although only remnant pools persist into the late dry season. This is consistent with observations made during the field surveys undertaken as part of the EIS Aquatic Ecology Report. It is also supported by surface water flow data collected from DRDMW’s surface water gauging stations located in the adjacent Watson River catchment, which indicate no perennial surface water flows in the vicinity of the project site.

As discussed in Section 5, the groundwater table typically rises in response to wet season rainfall. The groundwater table is typically at its highest (i.e. closest to ground level) a few weeks after the end of the wet season and, at this time, the groundwater depth ranges from ground level to approximately 8 m below ground level across the majority of the Mine Site and its surrounds. The groundwater table intersects the ground surface in seeps in the creek beds and in the headwaters of their tributaries. Locally, groundwater flows towards rivers and creeks where it seeps through the bed and high banks and provides baseflow.

As the dry season progresses, the groundwater table becomes progressively deeper. Towards the end of the dry season, when the groundwater table is at its deepest, the depth to groundwater is generally greater than 8 m below ground level across the majority of the Mine Site and its surrounds. The groundwater table typically continues to intersect some sections of the creek beds throughout the dry season.

As explained in Section 6.3.4, the project is not predicted to result in any significant change in groundwater seepage as baseflow. Enhanced recharge and mounding of groundwater in the open cut mining areas, in-pit fines backfill areas, Tapplebang Dam, and the FCA are predicted to result in localised changes in baseflow during mining operations. However, after decommissioning of the FCA and Tapplebang Dam, and cessation of mining operations, the localised changes in baseflow are predicted to diminish. As discussed above, the project is not predicted to result in any significant change in groundwater seepage to baseflow during the post mining phase, once the groundwater system has reached an equilibrium.

The predicted changes in baseflow to Tapplebang Creek during mining average an additional 10.5 ML/day in the dry season and a reduction of 6.1 ML/day in the wet season, or a change of 3.7% and -4.1% respectively. Predicted changes in baseflow to Coconut Creek average an additional 13.2 ML/day in the dry season and an additional 6.7 ML/day in the wet season, or a change of 6.1% and 5.6% respectively. The reduction in baseflow predicted in Tapplebang Creek in the wet season is due to the presence of water in Tapplebang Dam, which acts to change the hydraulic gradient between the creek and surrounding groundwater. Without the dam, groundwater usually seeps into the creek when the water table is higher than the creek level.

Predicted changes to baseflow in Tapplebang Creek and Coconut Creek are not expected to have a measurable effect on the natural flow regime in these creeks, and the changes are expected to be indistinguishable within the context of the significant natural year-to-year variations in total water flow in these creeks. Hence, the project's effects on groundwater are not expected to give rise to adverse impacts on any aquatic habitats/ecosystems associated with watercourses and drainage features, nor any downstream surface water users (including Arraw Dam located on Norman Creek, the approved future Amrun Mine abstraction site located on the Ward River, and use of surface waters by locals). The EIS Aquatic Ecology Report provides a detailed assessment of the impacts on aquatic ecosystems and habitats.

6.4.4 Impacts on Wetlands

There are no wetlands or other surface water features (that are not directly associated with creeks) located within the maximum predicted extents of drawdown and mounding. Hence, no impacts on wetlands or other surface water features are predicted.

6.4.5 Impacts on Groundwater Dependent Ecosystems

The impacts on Groundwater Dependent Ecosystems within, or in proximity to, the project site, are discussed in the EIS Terrestrial Ecology Report.

The EIS Terrestrial Ecology Report concludes that vegetation across the majority of the Mine Site is likely to use groundwater seasonally when the groundwater table is within 8 m of the ground surface (i.e. within the depth of tree roots). Groundwater is generally within 8 m of the ground surface during the post-wet season. As the dry season progresses, the groundwater table becomes progressively lower. Towards the end of the dry season, when the groundwater table is at its lowest, the depth to groundwater is generally greater than 8 m below ground level across the majority of the Mine Site and its surrounds.

The project's predicted effects on groundwater levels are described in Section 6.3. Open cut mining activities and in-pit fines backfilling will result in minor long-term changes to the groundwater depth in the Mine Site and the surrounding area. In general, during the post-wet season, the depth to groundwater will decrease (i.e. the groundwater table will be shallower) relative to pre-mining groundwater levels.

Following the completion of mining, the post-wet season groundwater table is predicted to remain within 8 m of the ground surface across the majority of the Mine Site and its surrounds (i.e. vegetation would continue to be able to seasonally access groundwater). However, there are a small number of discrete areas where the long-term, post mining groundwater table will be marginally deeper than 8 m below ground level during the post-wet season. The affected areas are shown in Figure 43 and comprise a total area of 20.7 ha. In these areas, the existing post-wet season groundwater depth is typically between 7 m and 8 m below ground level. The post-wet season groundwater depth in these areas will typically increase to between 8 m and 9 m below ground level post mining. This means that the post mining groundwater table would be below the depth of taproots of Darwin Stringybark, which dominates the primary vegetation community within the Mine Site and surrounds.

However, the EIS Terrestrial Ecology Report concludes that the vegetation at the Mine Site is well adapted to surviving extended periods with no rainfall and no access to the groundwater table, and it is expected to make seasonal use of groundwater. Hence, the minor and highly localised changes to groundwater elevation and depth are not expected to result in significant adverse impacts to the condition of vegetation in the areas shown in Figure 43.

The project is not predicted to give rise to any impacts on vegetation within the Product Bauxite Transport Corridor.

6.5 Cumulative Impacts

The Amrun Mine adjoins the Mine Site boundary to the west and north (Figure 4). There are no other approved resource projects within the vicinity of the Mine Site that could contribute to cumulative impacts.

The potential impacts of the Amrun Mine on the groundwater regime in the region were considered in relation to the potential for cumulative impacts with the project.

The South of the Embley Project EIS includes a groundwater study for the Amrun Mine. The South of the Embley Project EIS groundwater study assessed the groundwater impacts arising from:

- Open cut mining operations. The approved Amrun Mine operations are described in the South of the Embley Project EIS and Supplementary EIS (SEIS). The South of the Embley Project SEIS indicates that the Amrun Mine operations will involve only limited mining adjacent to the Mine Site boundary during years 1 to 13 of the mine life. The extent of the mining activities in the vicinity of the Mine Site boundary expand between years 14 and 40 of the mine life.
- The operation of the Amrun Mine groundwater supply borefield. As discussed in Section 4.1.1, the Amrun Mine groundwater supply borefield comprises seven artesian groundwater supply bores located more than 6 km west of the Mine Site boundary. The Amrun Mine groundwater supply borefield targets the deep GAB aquifers of the Carpentaria Basin (specifically the Gilbert River Formation) at depths of up to approximately 1 km below ground level.

It should be noted that there is insufficient publicly available data to accurately represent the Amrun Mine and reproduce its approved groundwater effects using the Aurukun Bauxite Project groundwater model. In the absence of the required data, significant unsupported assumptions would be necessary, thus undermining the robustness of the Aurukun Bauxite Project groundwater model.

Notwithstanding, the effects of the open cut mining operations and the operation of the Amrun Mine groundwater supply borefield on the groundwater regime are described in the South of the Embley EIS groundwater study. The groundwater study concluded that:

- Open cut mining operations at Amrun Mine are not predicted to result in any significant impact on the shallow groundwater table (associated with the bauxite ore and the Bulimba Formation) or baseflow associated with groundwater seepage to creeks.
- The Amrun Mine groundwater supply borefield is predicted to result in up to 120 m of depressurisation in the Gilbert River Formation. The zone of depressurisation associated with the Amrun Mine groundwater supply borefield operation is predicted to extend laterally more than 50 kilometres within the Gilbert River Formation. The zone of depressurisation is not predicted to extend upward into the overlying Bulimba Formation or the shallow groundwater regime due to the significant thickness (approximately 1 km) of low permeability sediments that separate the Gilbert River Formation from the Bulimba Formation and the shallow groundwater regime.

Hence, the Amrun Mine has been approved on the basis that it will have no significant impacts on the shallow groundwater regime. Conversely, the maximum predicted groundwater effects of the Aurukun Bauxite Project are limited to the shallow groundwater regime only. Hence, the groundwater effects of the project and the Amrun Mine do not overlap, and there is no potential for the project to contribute to cumulative effects on groundwater levels or cumulative impacts on groundwater users and sensitive environmental features.

6.6 Impacts on Groundwater Quality

The key potential sources of groundwater contamination from the project include:

- Seepage of pit water from open cut mining areas;
- Seepage of fines leachate from in-pit fines backfill areas;
- Seepage of fines leachate from the FCA; and
- Spillage of hydrocarbons and chemicals in storage areas.

The groundwater quality effects and associated impacts of these sources are discussed in Sections 6.6.1 to 6.6.4.

The final landform and post mining drainage arrangement is described in the PRC Plan prepared by the proponent and included in the EIS. The PRC Plan concludes that the final landform is free-draining.

The establishment of a free-draining final landform avoids the creation of final void lakes and any associated potential groundwater quality effects.

Groundwater monitoring will be undertaken to confirm the groundwater quality throughout the proposed operations. The groundwater monitoring program is described in Section 7 and has been designed to detect any unanticipated seepage and/or water quality issues.

6.6.1 Seepage of Pit Water from Open Cut Mining Areas

The mine drainage layout and water management system (WMS) are described in the EIS Surface Water Section. The mine drainage layout and WMS will generate pit water from open cut mining areas. Pit water will comprise direct rainfall to the open cut mining areas, runoff from the open cut mining area catchments, and seasonal groundwater inflows where pits intersect the groundwater table.

Pit water captured during mining operations will drain to the lowest part of each pit and be impounded against pit walls or collected in sumps excavated in the pit floor. The pit impoundments and collection sumps will be sized to provide the design volumes required by the International Erosion Control Association (IECA) Best Practice Erosion and Sediment Control guidelines. For all pits there is sufficient storage volume for effective sediment removal. This design will ensure the settlement of suspended sediment in accordance with IECA guidelines prior to release.

Any pit water that accumulates will evaporate, or dissipate passively via infiltration through the pit floor in response to the annual wet and dry season rainfall cycle. A proportion of the pit water that infiltrates the pit floor will recharge the local groundwater table.

The EIS Geochemistry Report characterised water quality in the bauxite and pit floor materials. Table 5 provides a summary of these geochemistry results and a summary of the natural groundwater quality characteristics for comparison. The report concludes the bauxite and pit floor materials will generate non-saline seepage and runoff, typically low in metals, with similar pH to regional groundwater.

Expected runoff and seepage from pit floor materials will be mixed with, and diluted by, direct rainfall and seasonal inflows of natural groundwater in the open cut mining areas. Since bauxite and pit floor materials water quality is shown to be commensurate with natural groundwater quality, any pit water movement away from the open cut mining areas is unlikely to result in significant change to surrounding groundwater quality or impact groundwater users or sensitive environmental features. Since predicted changes to baseflow rates in the Tapplebang Creek and Coconut Creek caused by seepage into groundwater are within natural variability (refer to Section 6.4.3), increases to baseflow in Tapplebang Creek and Coconut Creek induced by seepage are not anticipated to affect surface water quality.

Table 5 Comparison of Natural Groundwater Quality and to Project Geochemistry Results

Quality Characteristic	Natural Groundwater			Pit Floor Materials	Bauxite	Fines Supernatant	Fines Dry Season Seepage			Fines Wet Season Seepage		
	Min	Max	Mean				Min	Max	Mean	Min	Max	Mean
Physical Parameters												
In-situ pH	4.06	10.27	5.85	5.5	5.8	7.11	6.71	7	6.8	6.36	6.8	6.55
In-situ EC (µS/cm)	18.5	384.4	74.3	2	4	86.5	77	113	99.17	31	57	39.17
Total Alkalinity (mg/L)	3	155	25.8	-	-	12.5	10	29	18.8	5	9	7.3
Major Ions (Dissolved)												
Calcium (mg/L)	<0.5	36	2.08	<2	<2	3.5	2	5	4.17	1	2	1.5
Magnesium (mg/L)	<0.5	5	0.78	<2	<2	2	2	4	2.83	<1	1	-
Sodium (mg/L)	1	87	13.5	<2	<2	10	10	14	11.33	4	7	5.17
Potassium (mg/L)	<0.5	7.1	0.84	<2	<2	<1	<1	3	-	<1	<1	<1
Sulfate (mg/L)	<0.3	165	5.87	<2	<2	6.5	3	6	4.67	1	2	1.5
Chloride (mg/L)	<1	22	5.71	<2	<2	13.5	15	27	21.67	5	15	8
Dissolved Metals and Metalloids												
Aluminium (mg/L)	<0.01	1.3	0.066	<0.02	<0.02	<0.01	<0.01	0.01	-	<0.01	0.02	-
Arsenic (mg/L)	<0.001	0.005	0.001	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium (mg/L)	<0.001	0.115	0.008	-	-	-	-	-	-	-	-	-
Beryllium (mg/L)	<0.001	0.001	0.001	-	-	-	-	-	-	-	-	-
Boron (mg/L)	<0.05	0.2	0.051	<0.2	<0.2	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Quality Characteristic	Natural Groundwater			Pit Floor Materials	Bauxite	Fines Supernatant	Fines Dry Season Seepage			Fines Wet Season Seepage		
	Min	Max	Mean				Min	Max	Mean	Min	Max	Mean
Cadmium (mg/L)	<0.0001	0.0004	0.0001	<0.002	<0.002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium (mg/L)	<0.001	0.048	0.0014	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt (mg/L)	<0.001	0.002	0.001	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (mg/L)	<0.001	0.028	0.002	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	-
Iron (mg/L)	<0.05	1.43	0.108	<0.2	<0.2	<0.05	<0.05	<0.05	<0.05	0.06	0.11	0.092
Lead (mg/L)	<0.001	0.005	0.001	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese (mg/L)	<0.001	0.224	0.017	<0.002	<0.002	<0.001	0.002	0.094	0.06	0.004	0.027	0.015
Mercury (mg/L)	<0.0001	0.0001	0.0001	-	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum (mg/L)	<0.001	0.017	0.0013	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel (mg/L)	<0.001	0.045	0.0017	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium (mg/L)	<0.01	0.01	0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium (mg/L)	<0.001	0.21	0.013	-	-	-	-	-	-	-	-	-
Uranium (mg/L)	<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	0.07	0.011	<0.02	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (mg/L)	<0.005	0.058	0.011	<0.01	<0.01	<0.005	0.009	0.024	0.02	<0.005	0.037	-

6.6.2 Seepage of Pit Water from In-Pit Fines Backfill Areas

The in-pit fines backfill areas will be constructed in several completed open cut mining areas.

Similar to the open cut mining areas, the in-pit fines backfill areas will generate pit water comprising direct rainfall, runoff from the contributing catchments, and seasonal groundwater inflows. In addition, the pit water generated by the in-pit fines backfill areas will include fines supernatant water, and seepage from stored fines materials.

Similar to the open cut mining areas, pit water from in-pit fines backfill areas will dissipate passively via infiltration through the floor in response to the annual wet and dry season rainfall cycle. A proportion of the pit water that infiltrates the floor of the in-pit fines backfill areas will recharge the local groundwater table.

The EIS Geochemistry Report characterised supernatant and seepage waters from the fines materials. Table 5 provides a summary of the geochemistry results for expected fines supernatant water, as well as fines seepage water for the wet and dry seasons, and provides a summary of the natural groundwater quality characteristics for comparison.

The EIS Geochemistry Report concludes that the fines materials will generate non-saline seepage and runoff, typically low in metals, with similar pH to regional groundwater. As discussed above, runoff and seepage from fines materials will be mixed with, and diluted by, direct rainfall and seasonal inflows of natural groundwater in the open cut mining areas, reducing the potential for pit water infiltration to adversely impact groundwater quality.

As the expected fines supernatant and fines seepage water qualities for wet and dry seasons are commensurate with measured natural groundwater quality, it is concluded that seepage from in-pit fines backfill is not anticipated to affect the groundwater quality. Therefore, increases to baseflow in Tapplebang Creek and Coconut Creek induced by seepage (refer to Section 6.4.3) are likewise not anticipated to affect surface water quality.

6.6.3 Seepage from Fines Containment Area

The FCA will be constructed within the northern part of the Mine Site (Figure 2). The underlying geology and groundwater setting are consistent with the open cut mining areas and in-pit fines backfill areas.

The FCA will operate for three years (Project Years 1 to 3) before being decommissioned. During the operating life of the FCA, it will receive wet fines material from the Beneficiation Plant. The wet fines material will dry and consolidate primarily through evaporation. The deposited fines will also release a relatively small proportion of entrained contact water (also called 'bleed water') as it consolidates. The operating FCA will also receive significant volumes of direct rainfall to the operating FCA surface. Fines contact water and direct rainfall that infiltrates the fines material will dissipate via evaporation and infiltration through the floor of the FCA. A proportion of the FCA water that infiltrates the floor of the FCA will recharge the local groundwater table.

As discussed in relation to the in-pit fines backfill areas, the EIS Geochemistry Report characterised supernatant and seepage from the fines materials. The EIS Geochemistry Report concludes that the fines materials will generate non-saline seepage and runoff, typically low in metals, with similar pH to regional groundwater. The diluting effects of fresh rainfall are expected to be significant during the wet season, reducing the potential for pit water infiltration to adversely impact groundwater quality.

As with the in-pit fines backfill water quality discussed in Section 6.6.2, the water quality comparison between expected fines supernatant water, dry season seepage, wet season seepage, and natural groundwater indicates that expected seepage water quality is predicted to be commensurate with observed natural groundwater quality. Therefore, any water movement away from the FCA is unlikely to result in significant change to surrounding groundwater quality or impact groundwater users or sensitive environmental features.

6.6.4 Hydrocarbon and Chemical Storage

Hydrocarbon and chemical storage will be managed in accordance with the measures described in the EIS Health and Safety Section. Proposed management measures include adequate bunding or storage areas, and immediate clean-up of any spills. These measures are standard practice at mine sites and are designed to prevent the contamination of groundwater. Given the limited hydrocarbon and chemical storage activities proposed, and the controls that will be adopted, the project is not expected to give rise to groundwater contamination as a result of hydrocarbon and chemical contamination.

7 Groundwater Monitoring and Management

The proponent maintains a groundwater monitoring network comprising 21 monitoring bores located across the Mine Site (Figure 44). This groundwater monitoring network was designed to establish baseline groundwater levels and quality within the Mine Site.

The groundwater monitoring network established as part of EIS groundwater investigations will continue to be utilised throughout the life of the project to confirm the actual extent of groundwater impacts and validate the conservative groundwater modelling predictions presented in this report. The groundwater monitoring network is suitable for monitoring the effects of the project on the groundwater regime.

The monitoring program will involve groundwater level and quality monitoring, including the following:

- Groundwater levels will be recorded using continuous dataloggers, which will enable natural groundwater level fluctuations (such as seasonal responses to rainfall) to be distinguished from potential groundwater level impacts due to drawdown or mounding resulting from mining activities.
- Groundwater quality monitoring will be undertaken on a quarterly basis, access permitting. This will be used to detect any changes in groundwater quality. Water quality samples will be analysed for the following parameters:
    - pH, EC, and total dissolved solids;
    - Selected major ions (Ca^{+2}, Cl^{-}, and SO_4^{-2}) and alkalinity;
    - Dissolved metals and metalloids (Cu, Fe, Mn, and Zn); and
    - Total petroleum hydrocarbons (C_6 – C_9 and C_{10} – C_{36} fractions).
- Monitoring and sampling will be conducted by suitably qualified personnel. The collection, storage, and transport of water quality samples for laboratory analysis will be undertaken in accordance with the proponent's existing procedures, and in accordance with relevant guidelines and Australian Standards. A NATA accredited laboratory will conduct the water quality analyses.

The groundwater monitoring data will be reviewed periodically and reported to DES in accordance with the proponent's statutory obligations under the Water Act's underground water management framework.

Groundwater take will also be calculated and reported annually in accordance with the proponent's statutory obligations for exercising underground water rights under the MR Act.

8 Conclusions

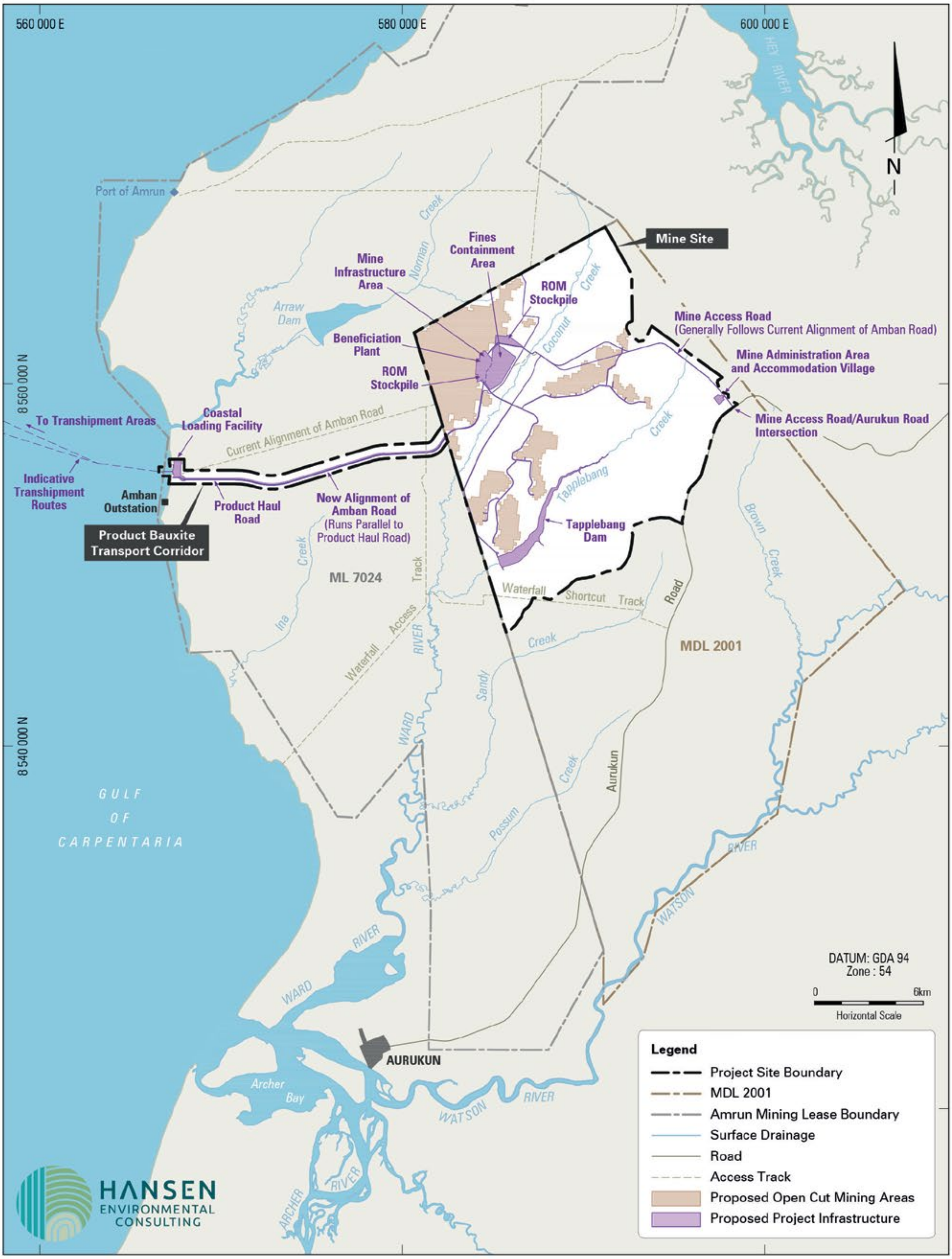
The key conclusions of the groundwater assessment are as follows:

- The local groundwater regime comprises a shallow aquifer that is predominantly located within the weathered Bulimba Formation. The shallow aquifer is hydraulically connected to the overlying bauxite ore. The shallow aquifer is underlain by up to approximately 1 km of lower permeability aquitards, which separate the shallow aquifer from the deep GAB aquifers (e.g. the Gilbert River Formation). The shallow aquifer is therefore hydraulically disconnected from the deep GAB aquifers in the vicinity of the project.
- The shallow groundwater table shows significant seasonal variability and is hydraulically connected to local creeks. Groundwater seepage from the shallow aquifer provides seasonal baseflow to creeks for much of each year.
- The project is predicted to result in minor, localised, and often temporary changes in groundwater levels in the vicinity of open cut mining areas and mine infrastructure. The predicted groundwater level changes will not result in any net groundwater take from the shallow aquifer or any significant long term change in creek baseflow. Hence, no groundwater users or other sensitive receptors are predicted to be adversely affected by the project effects on groundwater levels or creek baseflow.
- The project's predicted effects on groundwater levels in the shallow aquifer do not overlap with the predicted effects of the neighbouring Amrun Mine, which are limited to the deep GAB aquifer. Hence, there is no cumulative effect on the shallow aquifer and no potential for the project to contribute to cumulative impacts on any groundwater users or other features.
- The project is not expected to result in groundwater contamination.

AURUKUN BAUXITE PROJECT

Location Plan

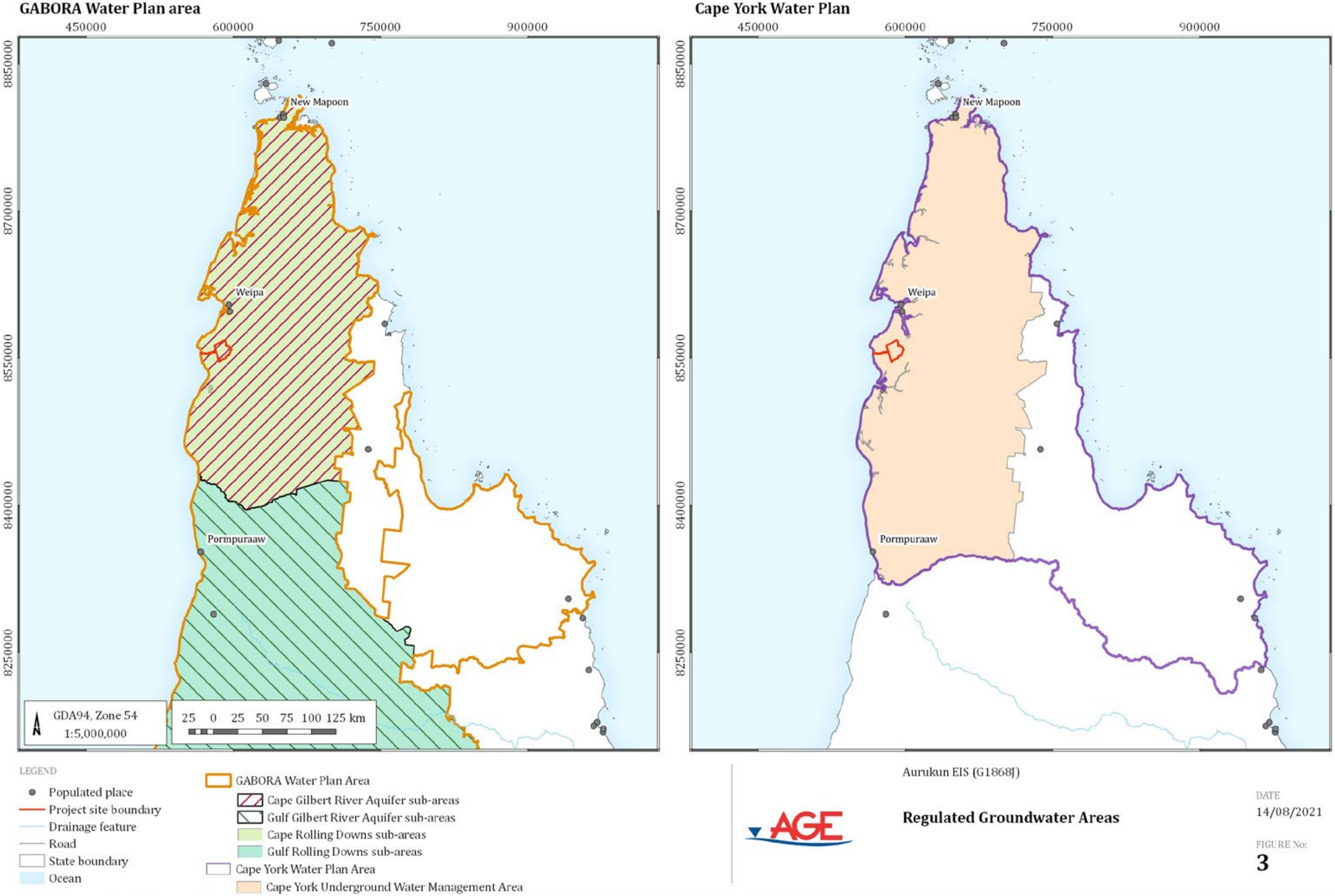
FIGURE 1



AURUKUN BAUXITE PROJECT

Conceptual Project Layout

FIGURE 2



Aurukun EIS (G1868J)

Regulated Groundwater Areas

DATE
14/08/2021

FIGURE No:
3

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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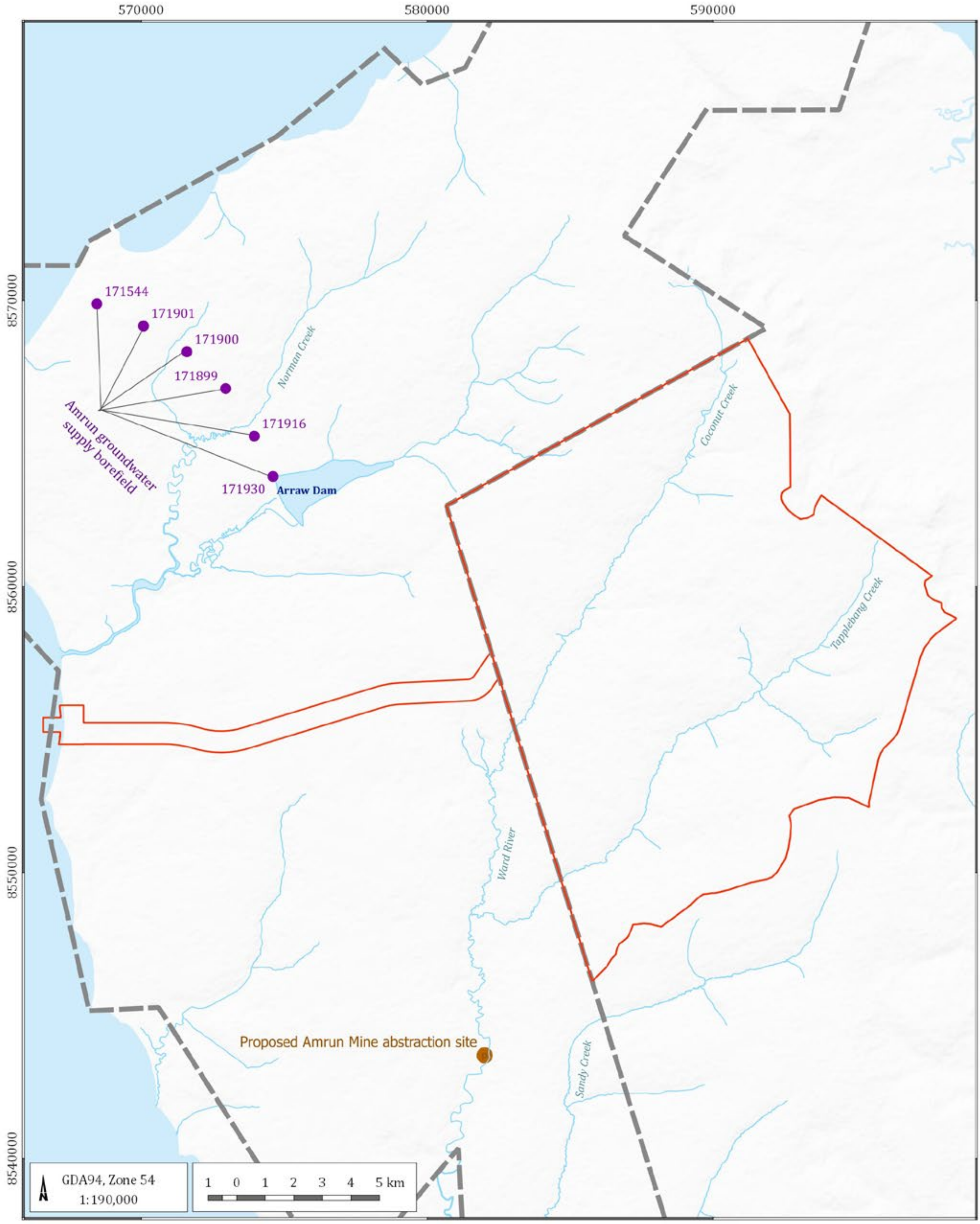


LEGEND

- ● Proposed Amrun Mine abstraction site
- ● Amrun Mine groundwater supply borefield
- — Drainage feature
- — Project site boundary
- ▨ Amrun Mine extent (ML 7024)

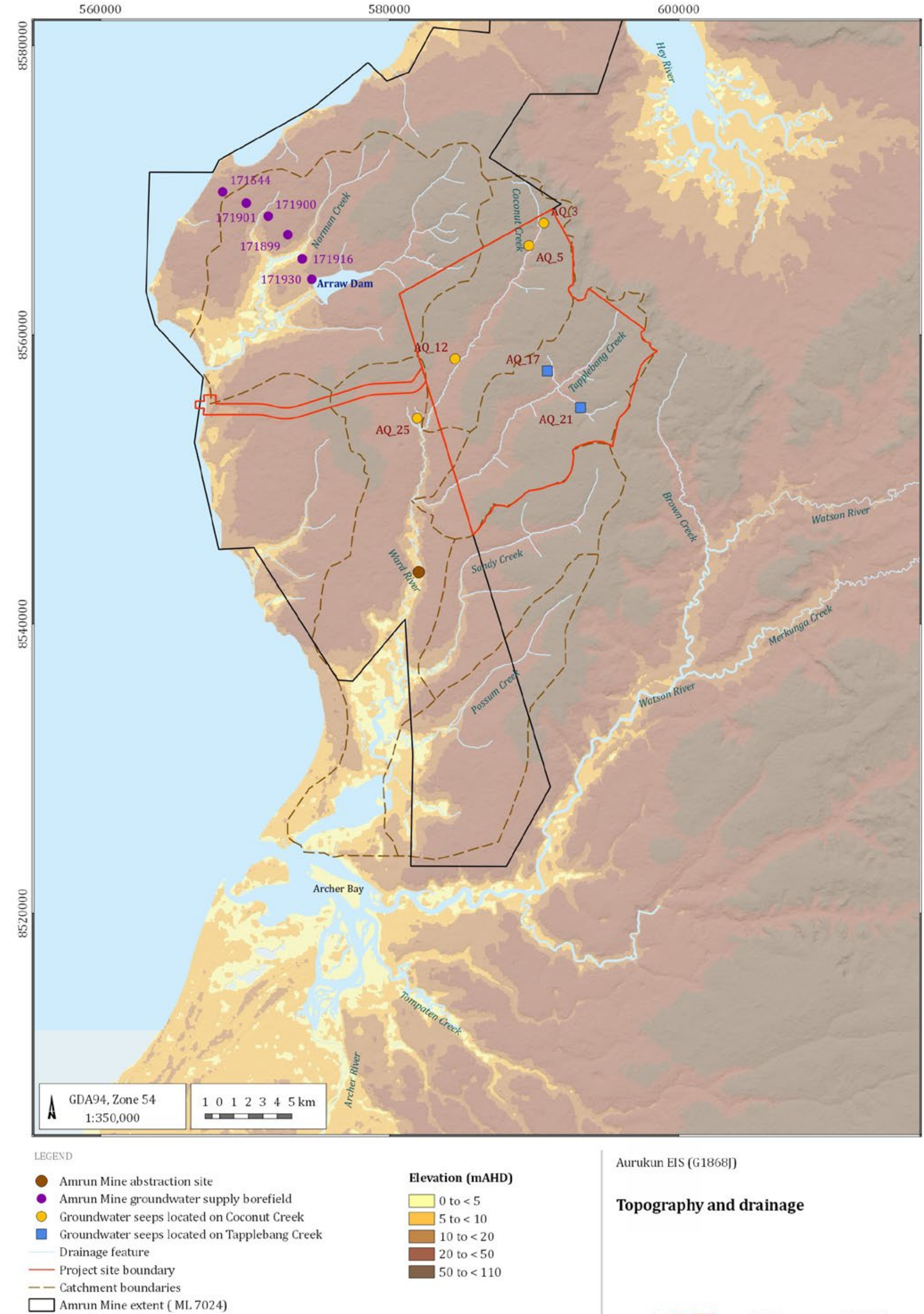
Aurukun EIS (G1868J)

Project Setting

DATE
13/08/2021

FIGURE No:
4

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
\\age-main01\Shared\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\04.00_G1868J_Project Setting.qgs



Aurukun EIS (G1868J)

Topography and drainage

DATE
13/08/2021

FIGURE No:
5

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\05.00_G1868J_Topography and drainage.qgs

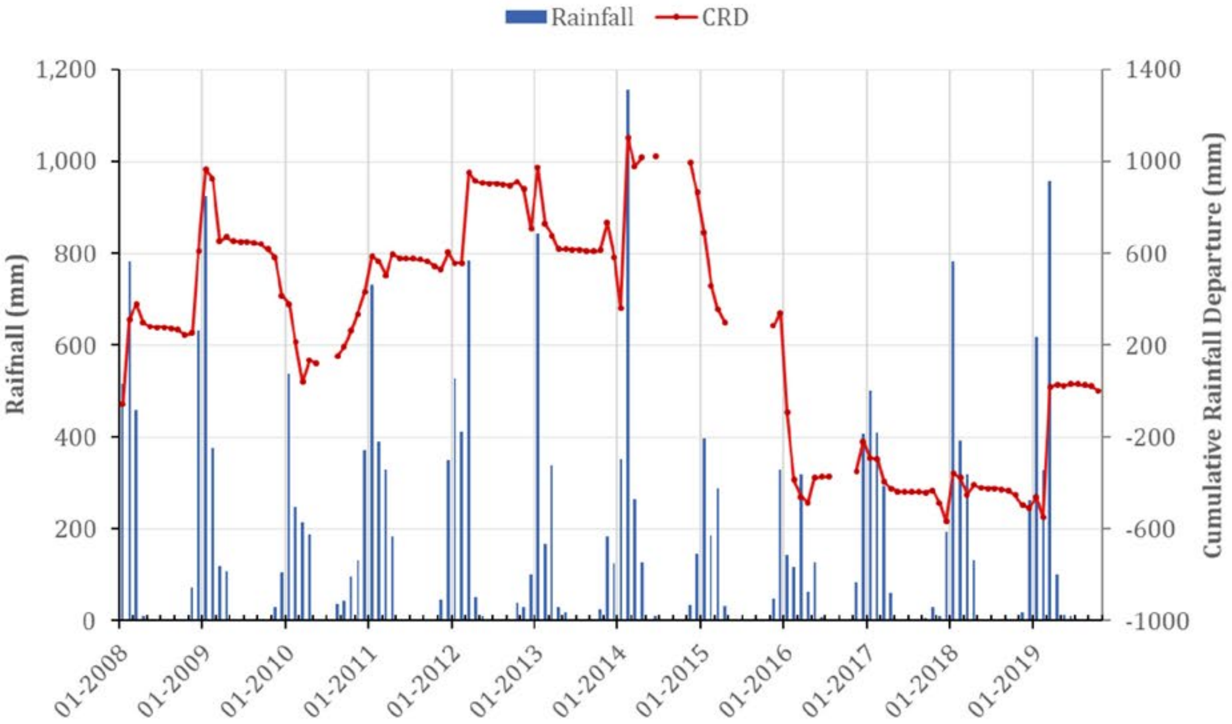


Figure 6 Monthly rainfall and CRD at Aurukun from 2008 to 2019

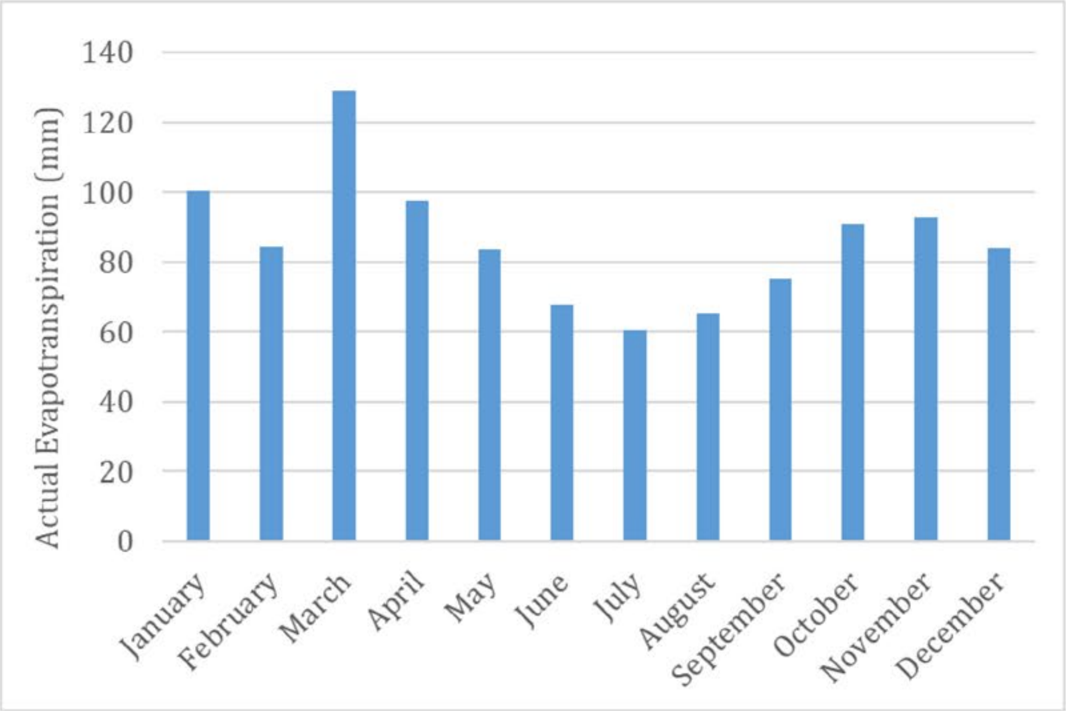
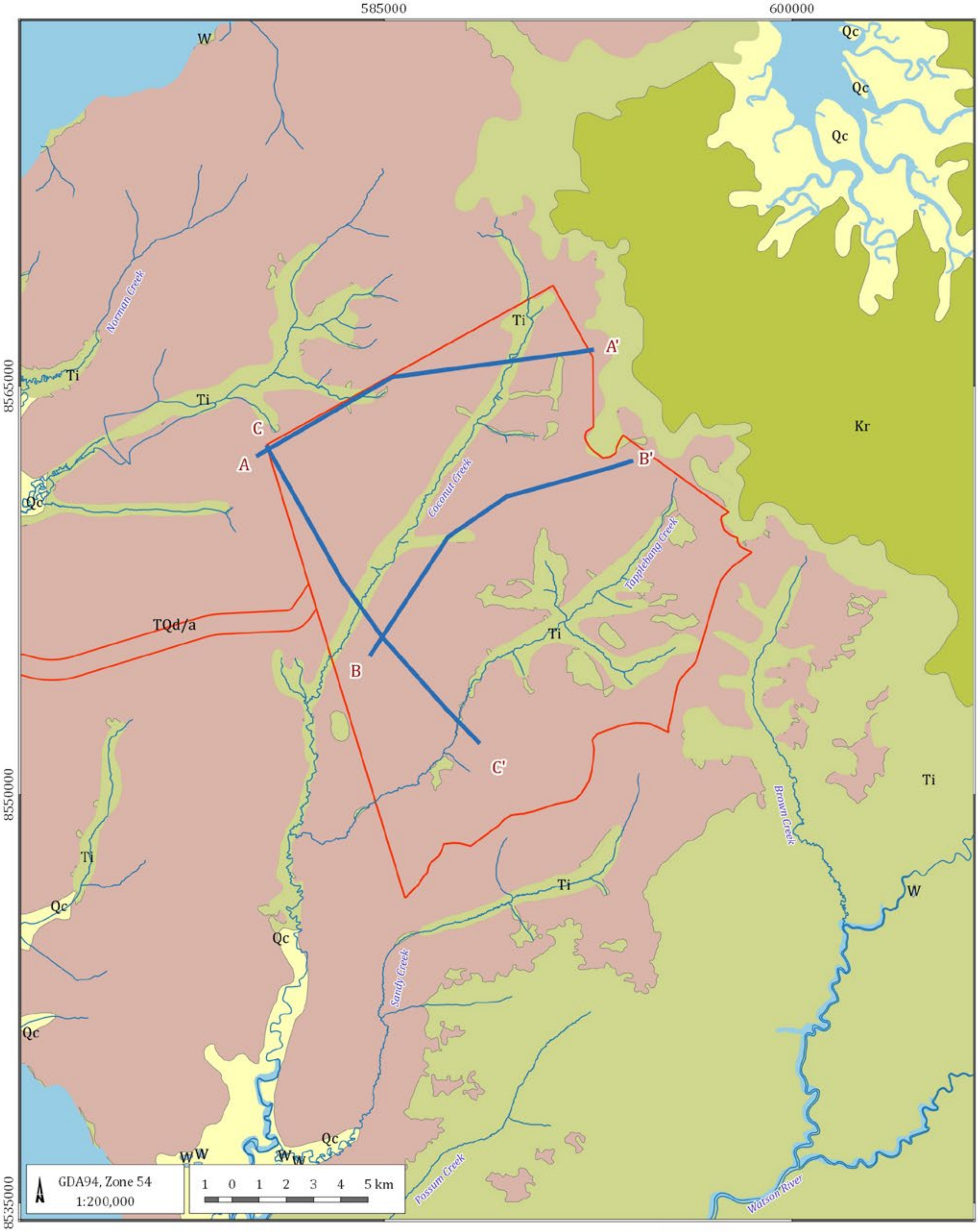


Figure 7 Monthly average actual aerial evapotranspiration (Source: BoM data 1961–1990)



LEGEND

- Cross section lines
- Drainage feature
- Project site boundary

State detailed surface geology (1:100k)

- 🟨 Alluvium (Qc)
- 🟫 Bauxite (TQd\a)
- 🟩 Weathered Bulimba Formation (Ti)
- 🟩 Rolling Downs Group (Kr)
- 🟦 Water body (W)

Aurukun EIS (G1868J)

Surface Geology

DATE	FIGURE No:
13/08/2021	**8**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1868J_Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\08.00_G1868J_Surface geology.qgs

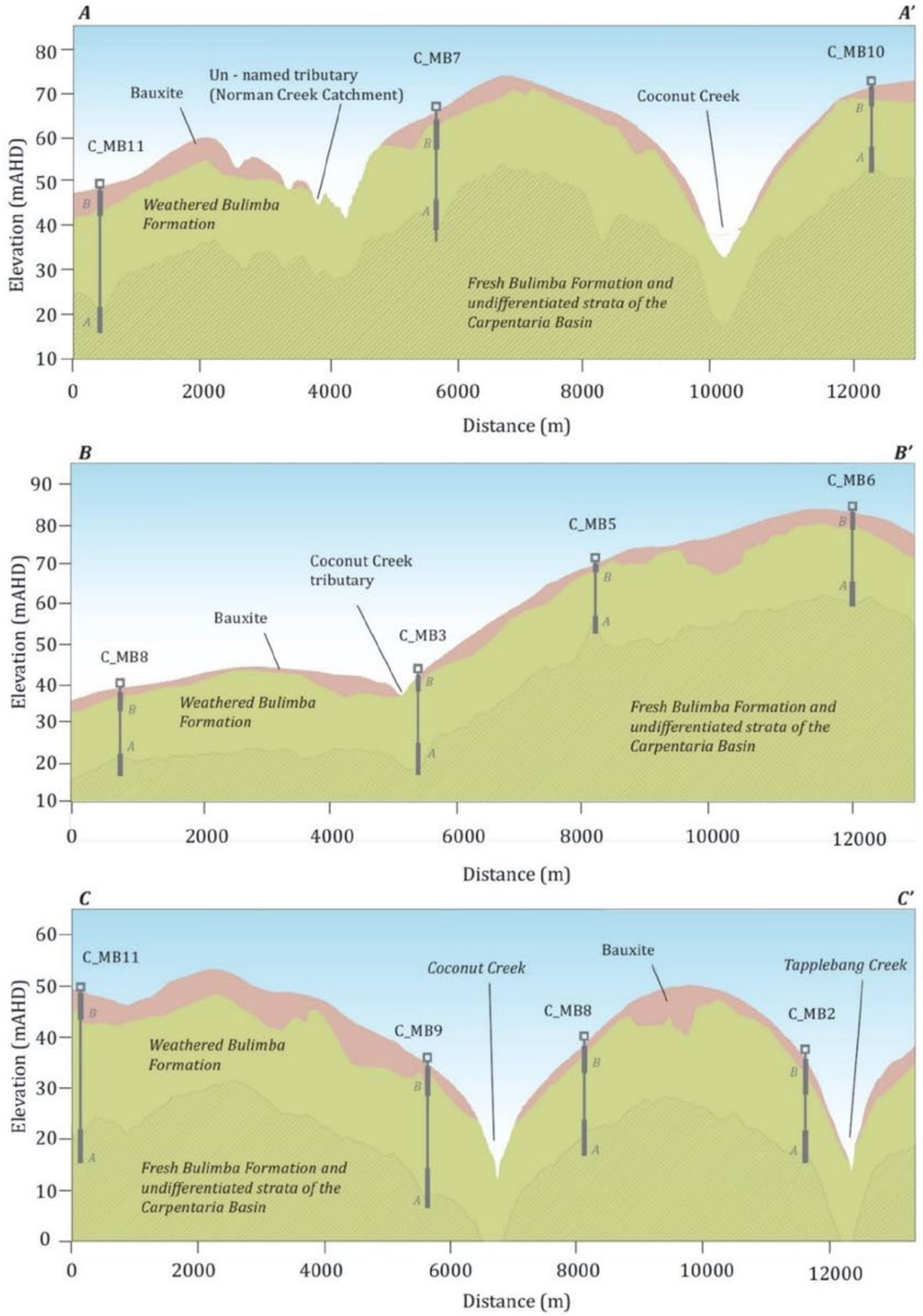
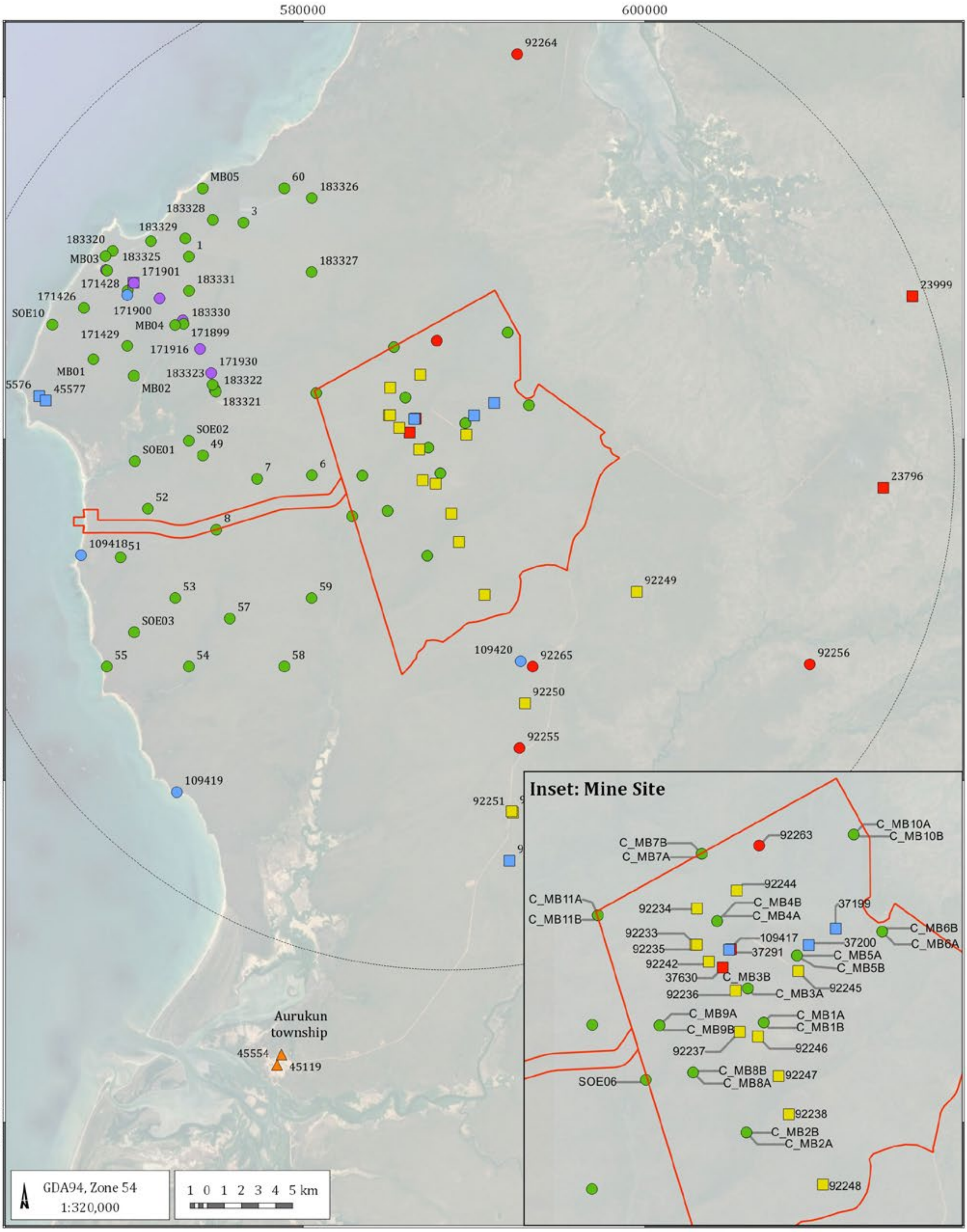


Figure 9 Geology Cross Sections



LEGEND

— Project site boundary

◌ Radius of 20 km from Mine Site boundary

Groundwater bores

- 🟪 Artesian water supply bore (abandoned/destroyed)
- 🟣 Artesian water supply bore (existing)
- 🟥 Government or exploration bore (abandoned/destroyed)
- 🔴 Government or exploration bore (existing)
- 🟦 Sub-artesian water supply bore (abandoned/destroyed)
- 🔵 Sub-artesian water supply bore (existing)
- 🟢 Monitoring bore (existing)
- 🟨 Uncategorised bore (abandoned/destroyed)
- ▲ Aurukun town water supply bores

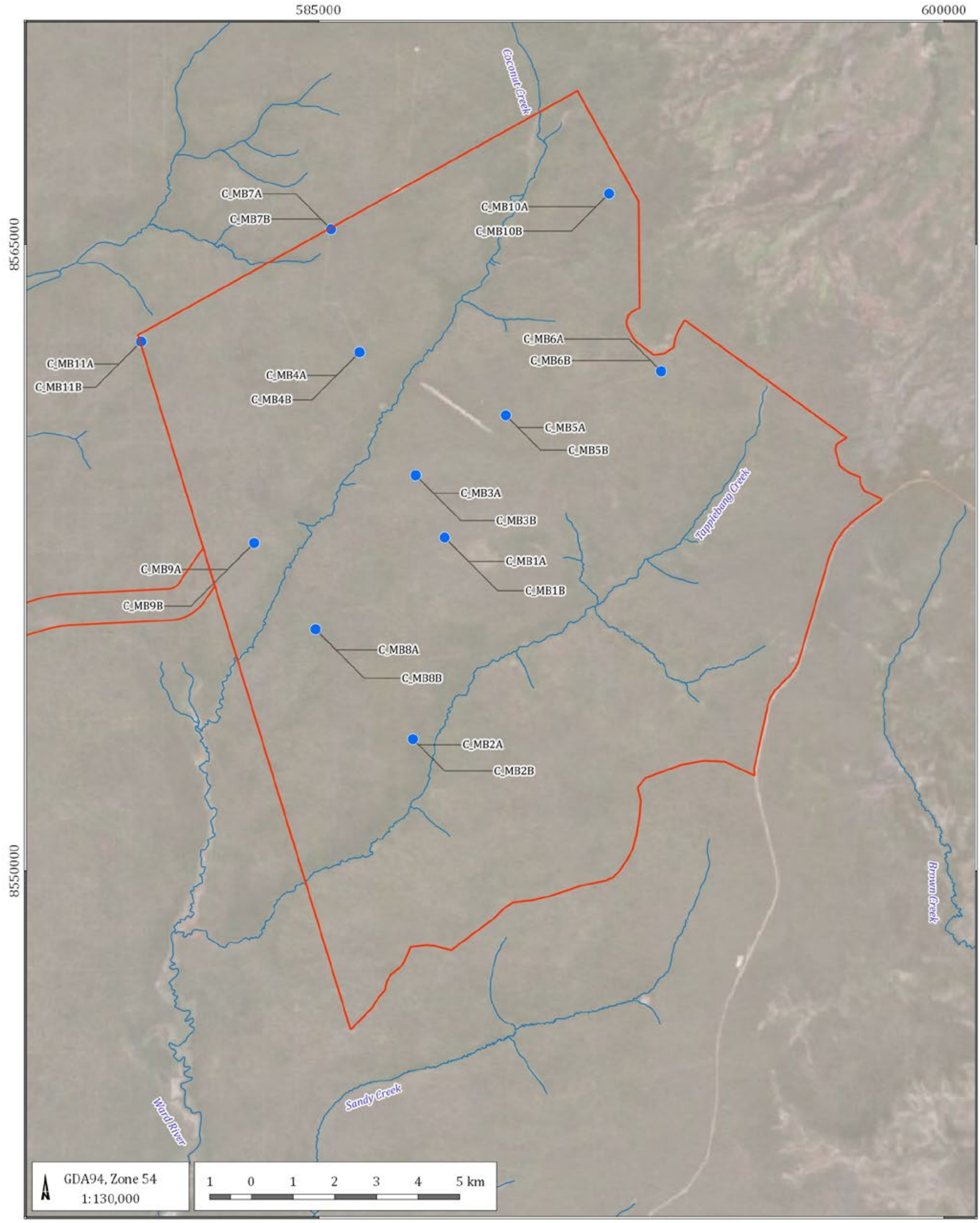
Aurukun EIS (G1868J)

Groundwater Bores

AGE

DATE	FIGURE No:
14/08/2021	**10**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\10.00_G1868J_Groundwater Bores_JKP.qgs



LEGEND

- ● Aurukun Bauxite Project Groundwater monitoring bore
- Drainage feature
- Project site boundary

Aurukun EIS (G1868J)

Site Investigation Layout

DATE 14/08/2021

FIGURE No: **11**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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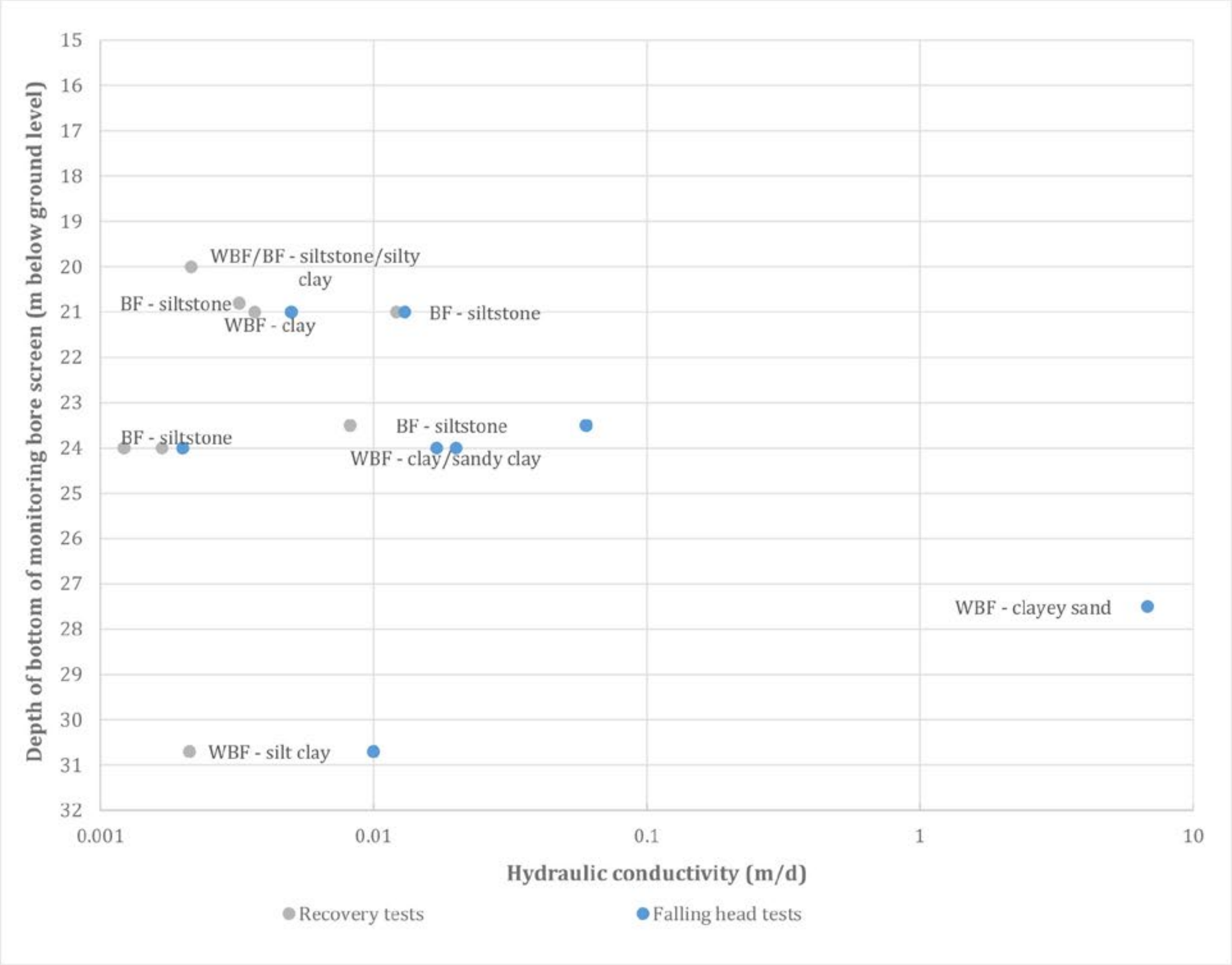


Figure 12 Hydraulic Conductivity Results relative to depth

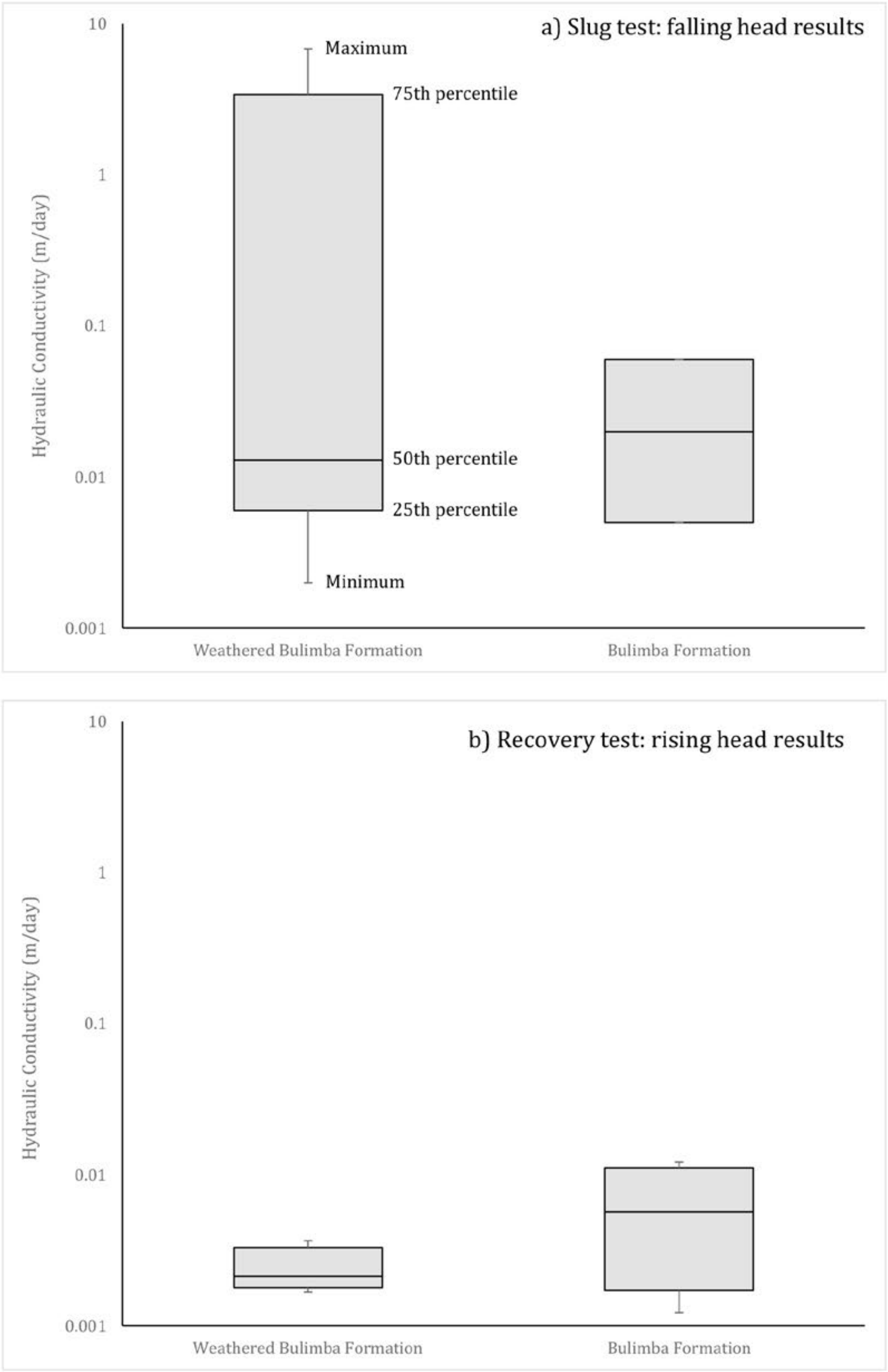


Figure 13 Hydraulic Conductivity Dataset

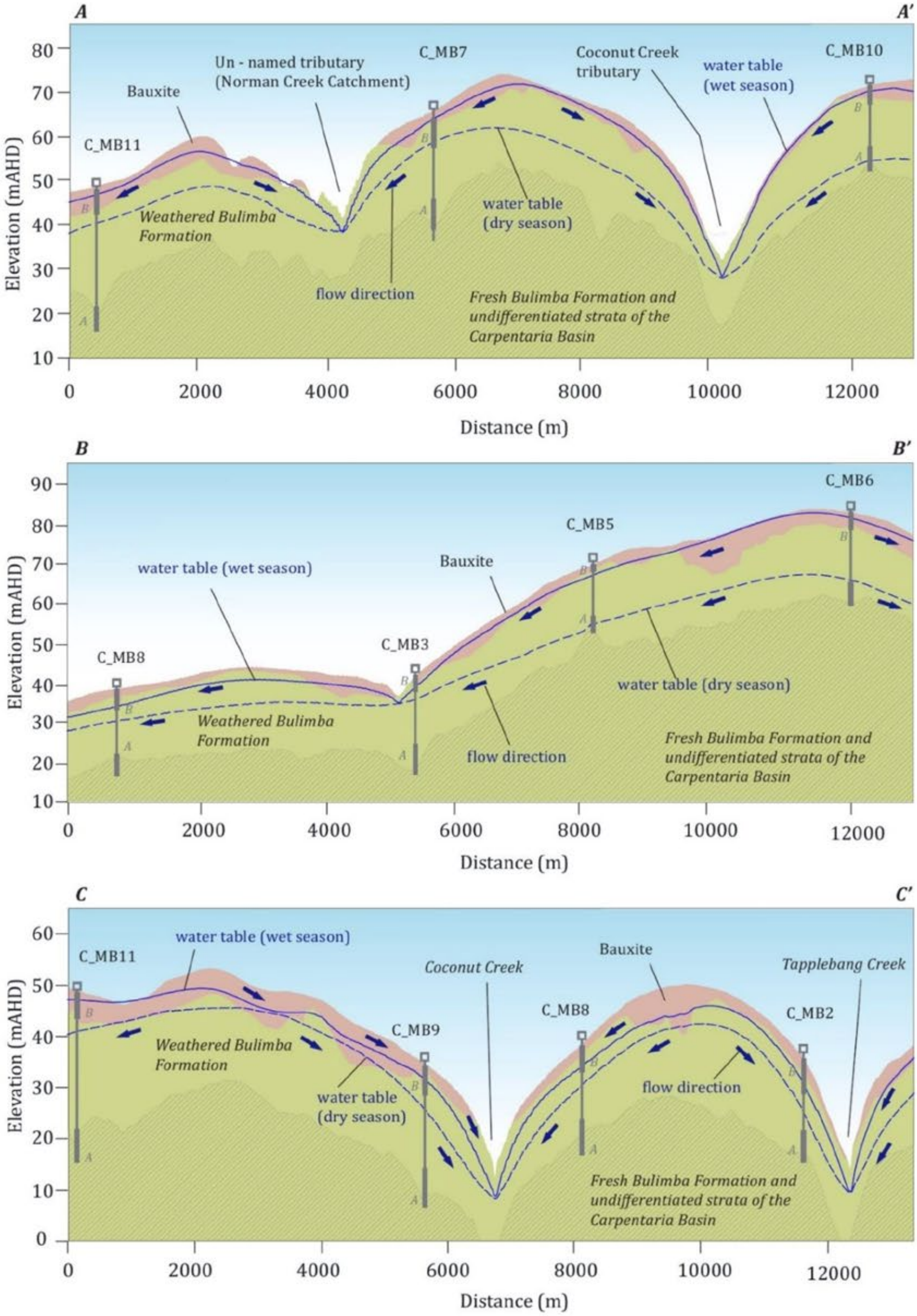
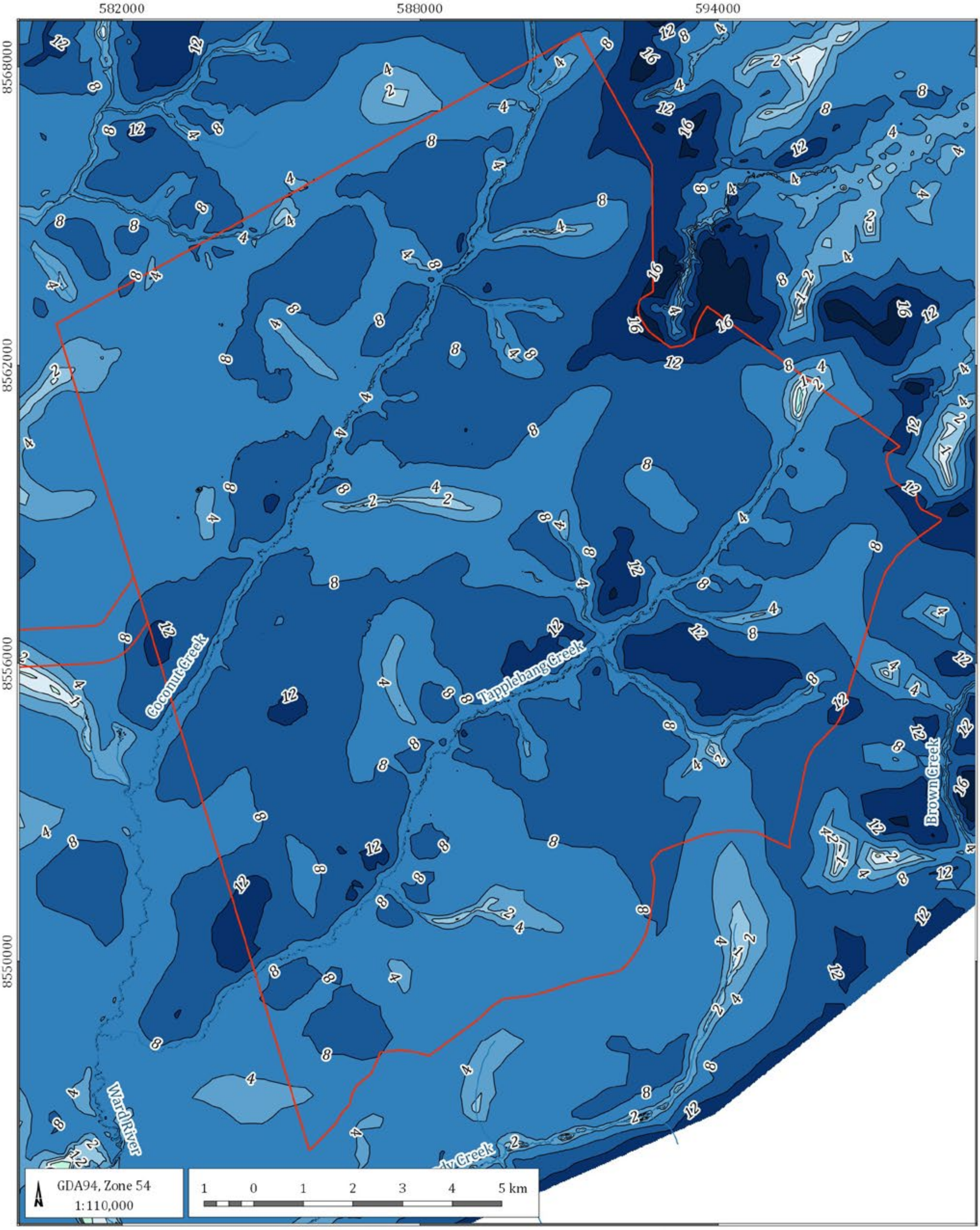


Figure 14 **Conceptual Groundwater Regime**



LEGEND

— Drainage feature
— Depth contour
(meters below ground level)
— Project site boundary

Depth to water table
(meters below ground level)

▨ At or above ground surface
▨ 0 to < 1
▨ 1 to < 2
▨ 2 to < 4
▨ 4 to < 8
▨ 8 to < 12
▨ 12 to < 16
▨ 16 to < 23

Aurukun EIS (G1868J)

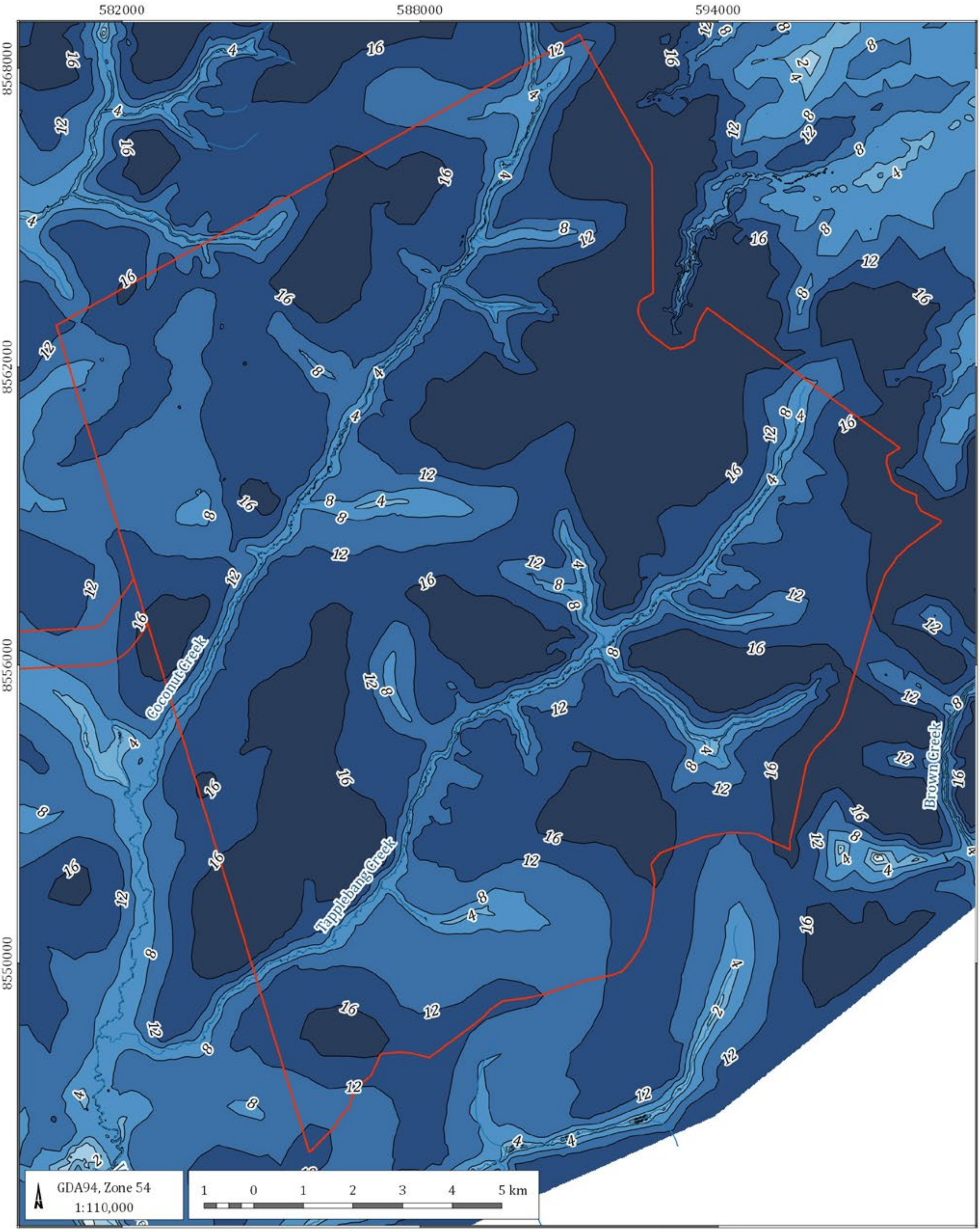
Median depth to water following wet season rainfall

AGE

DATE
13/08/2021

FIGURE No:
15

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\15.00_G1868J_Medain depth to water following wet season rainfall.qgs



LEGEND

- Drainage feature
- Depth contour (meters below ground level)
- Project site boundary
- Depth to water table (meters below ground level)

Depth to water table (meters below ground level)

▢	At or above ground surface
▢	0 to < 1
▢	1 to < 2
▢	2 to < 4
▢	4 to < 8
▢	8 to < 12
▢	12 to < 16
▢	16 to < 30

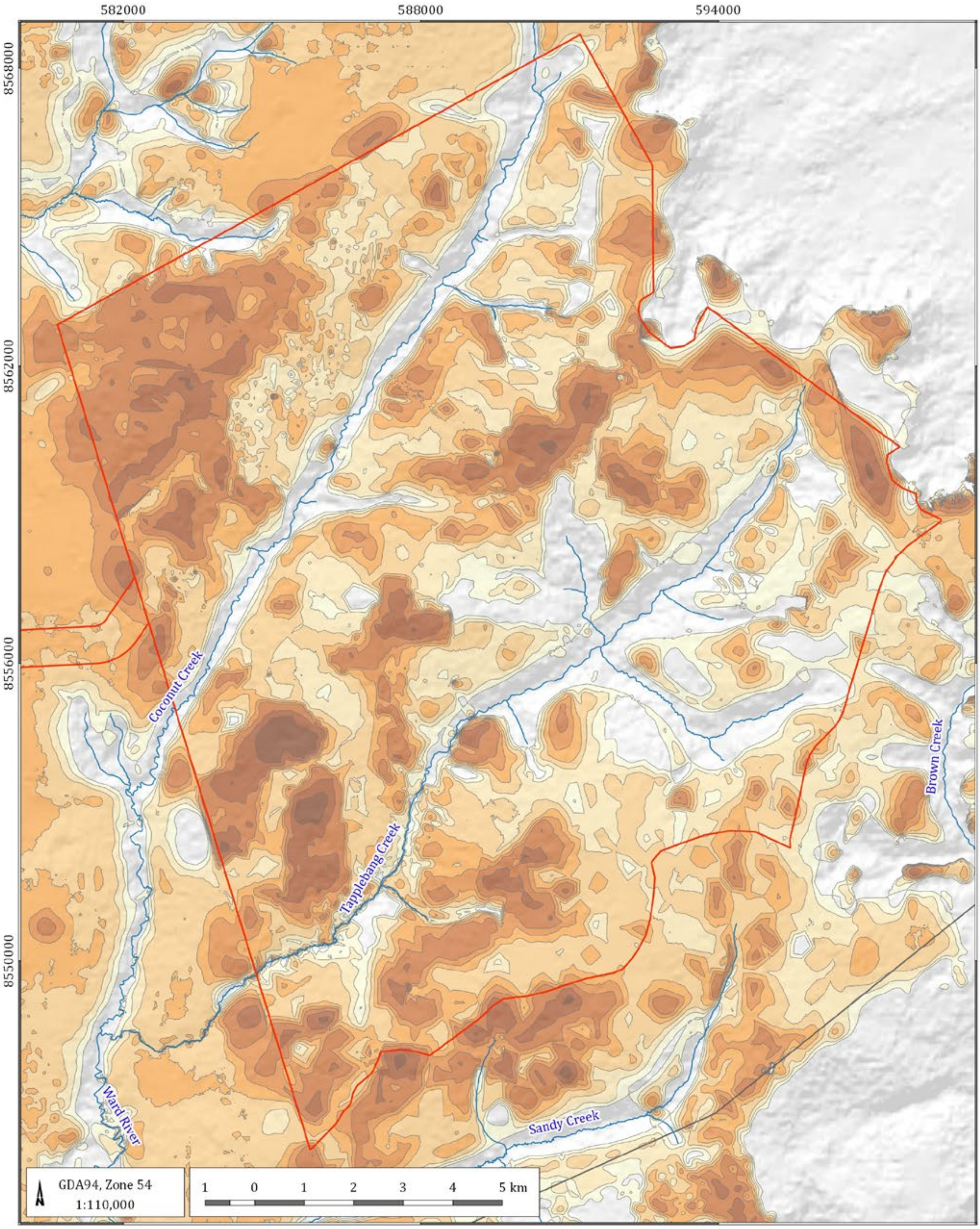
Aurukun EIS (G1868J)

Median depth to water following dry season

DATE 13/08/2021

FIGURE No: **16**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\15.00_G1868J_Medain depth to water following wet season rainfall.qgs



LEGEND

- Drainage feature
- Project site boundary
- ☐ Model domain boundary

Bauxite thickness (m)

- Not present
- 0 to < 1
- 1 to < 2
- 2 to < 3
- 3 to < 4
- 4 to < 5
- 5 to < 7
- 7 to < 10
- 10 to ≤ 16

Aurukun EIS (G1868J)

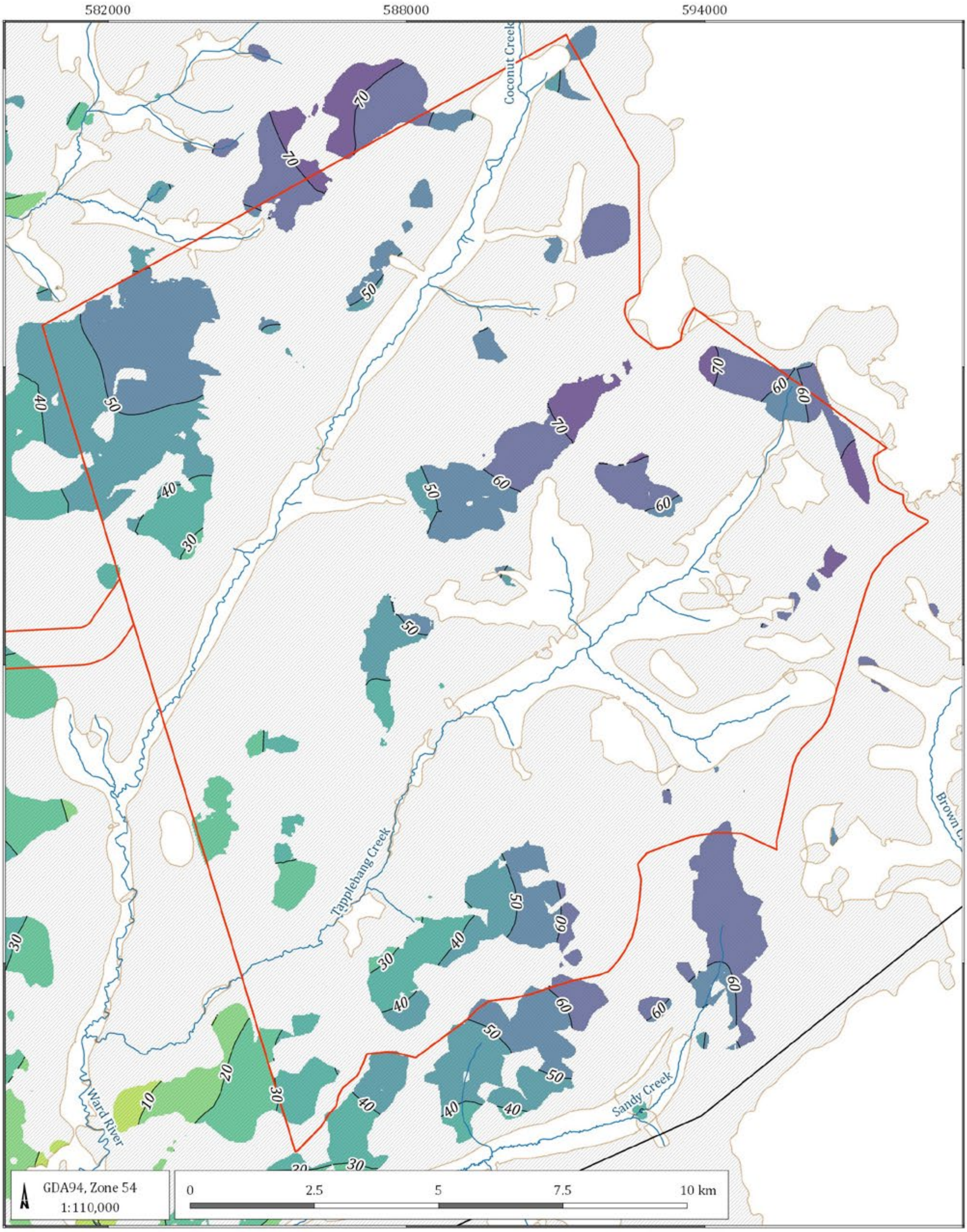
Bauxite Thickness and Extent

AGE

DATE 13/08/2021

FIGURE No: **17**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\17.00_G1868J_Bauxite thickness and extent.qgs



LEGEND

— Drainage feature

— Hydraulic head elevation contours

— Project site boundary

☐ Model domain boundary

▨ Bauxite extent

Hydraulic head elevation (mAHD)

- 🟨 < 0
- 🟩 0 to < 10
- 🟩 10 to < 20
- 🟩 20 to < 30
- 🟩 30 to < 40
- 🟦 40 to < 50
- 🟦 50 to < 60
- 🟪 60 to < 70
- 🟪 70 to < 80

Aurukun EIS - Model calibration review (G1868J)

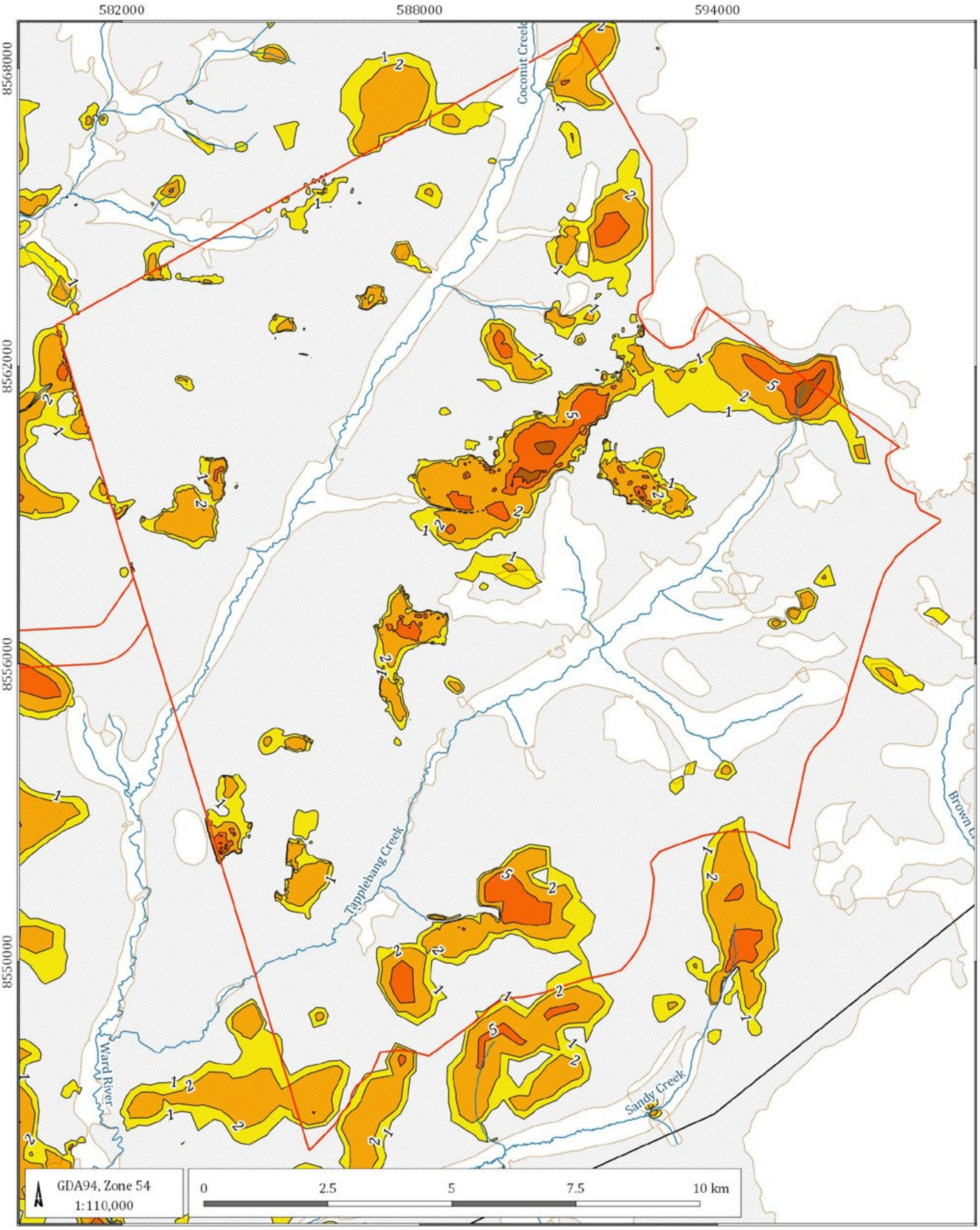
Hydraulic head in the bauxite following wet season rainfall

AGE

DATE
14/08/2021

FIGURE No:
18

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
\\age-main01\Shared\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\18.00_G1868J_Hydraulic head in the bauxite following wet season rainfall.qgs



LEGEND

- Drainage feature
- Saturation thickness contours
- Project site boundary
- ☐ Model domain boundary
- ▨ Bauxite extent

Saturation thickness (m)

- ☐ 0 to < 1
- 🟨 1 to < 2
- 🟧 2 to < 5
- 🟧 5 to < 10
- 🟫 10 to < 14

Aurukun EIS - Model calibration review (G1868J)

Saturated thickness of bauxite following wet season rainfall

AGE

DATE 13/08/2021

FIGURE No: **19**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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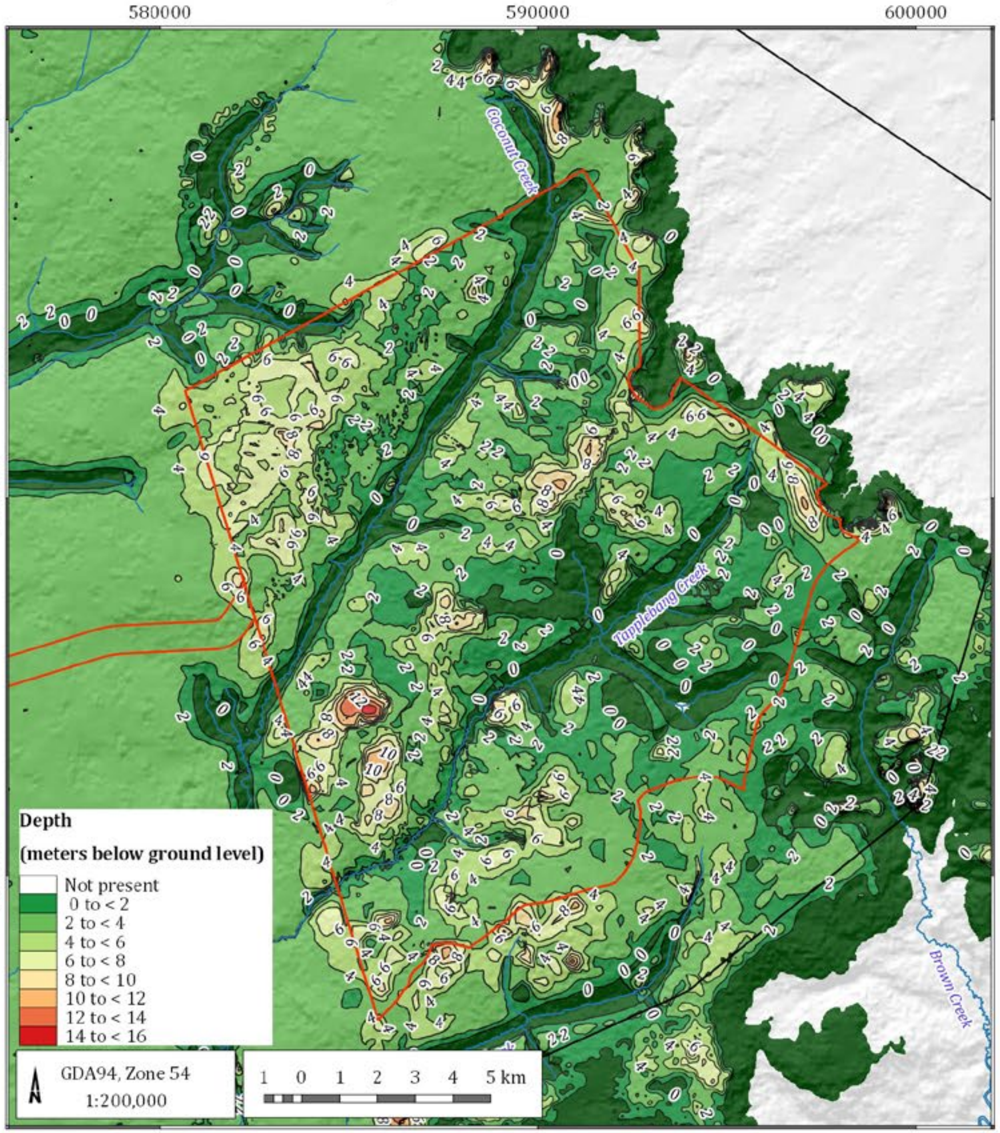
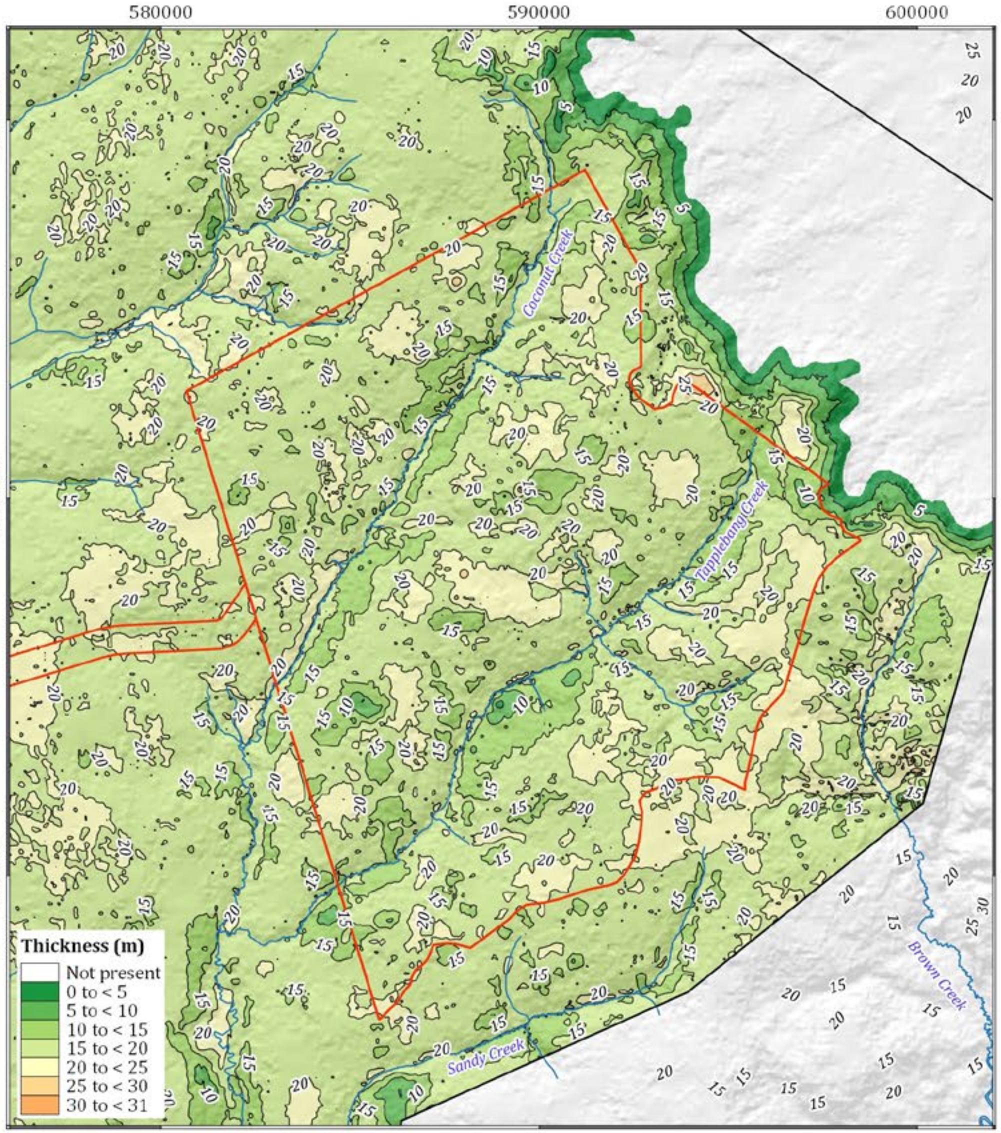
Weathered Bulimba Formation Depth



Weathered Bulimba Formation Thickness and Extent



LEGEND

- Drainage feature
- Contour line
- Project site boundary
- Model domain boundary

Aurukun EIS (G1868J)

Weathered Bulimba Formation Depth, Thickness and Extent

DATE
16/08/2021

FIGURE No:
20

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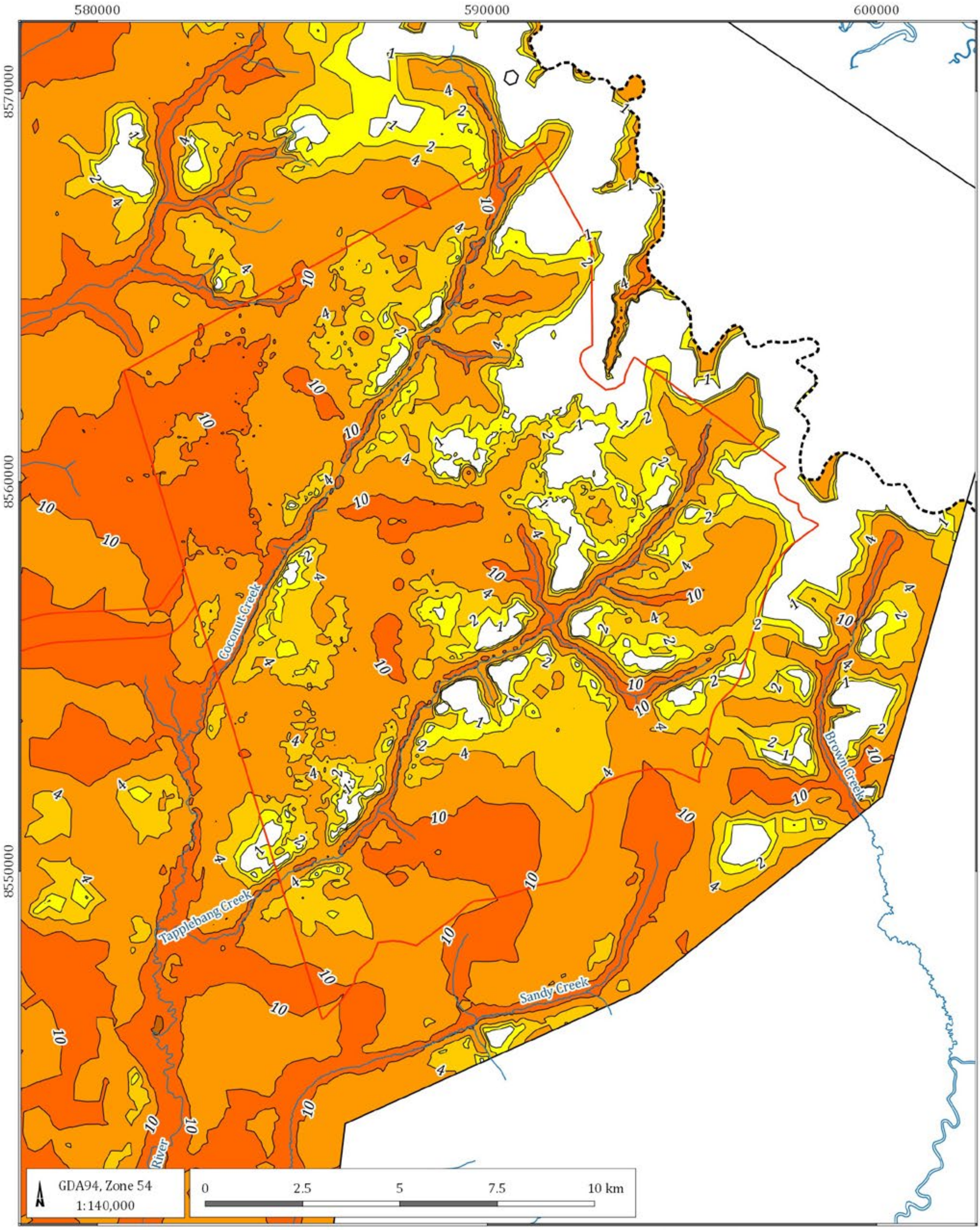
G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\20.00_G1868J_Weathered Bulimba Formation Depth,Thickness and Extent.qgs



LEGEND

- Drainage feature
- Project site boundary
- Saturation thickness contours
- Extent of weathered Bulimba Formation
- Model domain boundary

Saturation thickness (m)

☐	0 to < 1
🟨	1 to < 2
🟨	2 to < 4
🟧	4 to < 10
🟧	10 to < 22

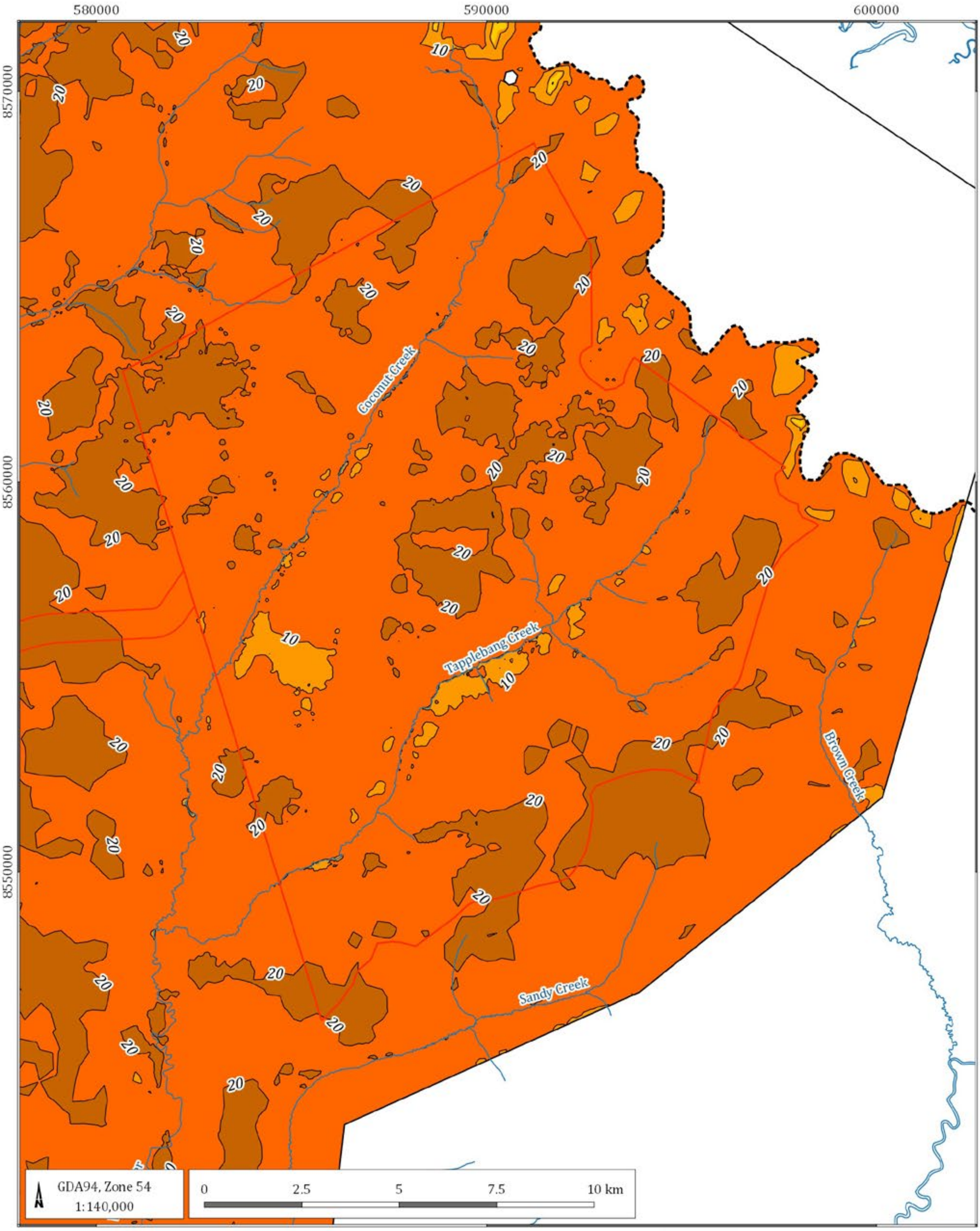
Aurukun EIS - Model calibration review (G1868J)

Saturated thickness of weathered Bulimba Formation following dry season

DATE
16/08/2021

FIGURE No:
21

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\21.00_G1868J_Saturated thickness of weathered Bulimba Formation following dry season.qgs



LEGEND

- Drainage feature
- Project site boundary
- Saturation thickness contours
- Extent of weathered Bulimba Formation
- Model domain boundary

Saturation thickness (m)

- ⬜ 0 to < 1
- 🟨 1 to < 2
- 🟨 2 to < 4
- 🟧 4 to < 10
- 🟧 10 to < 20
- 🟧 20 to < 31

Aurukun EIS - Model calibration review (G1868J)

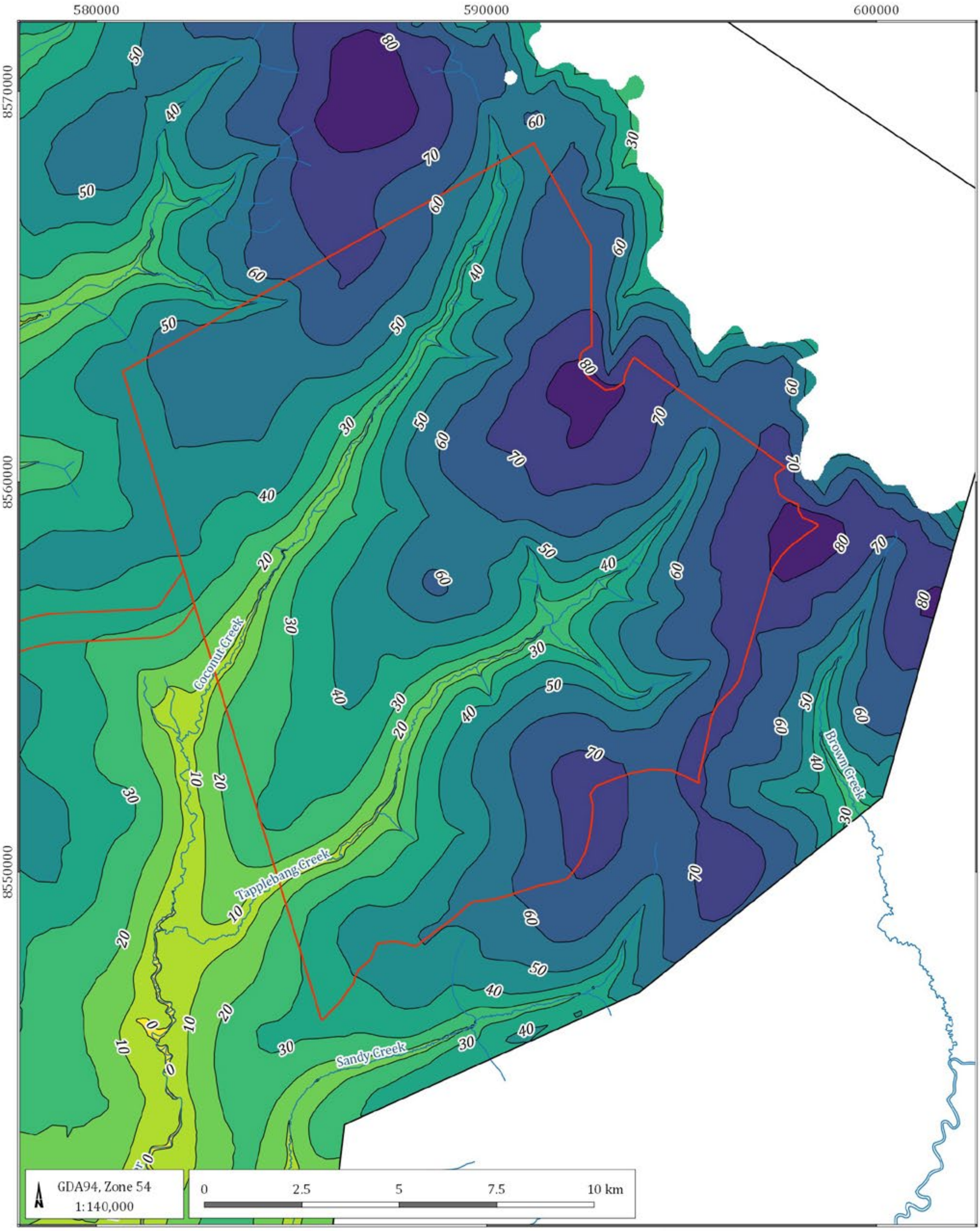
Saturated thickness of weathered Bulimba Formation following wet season rainfall

AGE

DATE 13/08/2021

FIGURE No: **22**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\21.00_G1868J_Saturated thickness of weathered Bulimba Formation following dry season.qgs



LEGEND
- Drainage feature
- Project site boundary
- Hydraulic head elevation contours
- ☐ Model domain boundary

Hydraulic head elevation (mAHD)

- 🟨 < 0
- 🟩 0 to < 10
- 🟩 10 to < 20
- 🟩 20 to < 30
- 🟩 30 to < 40
- 🟦 40 to < 50
- 🟦 50 to < 60
- 🟦 60 to < 70
- 🟪 70 to < 80
- 🟪 80 to < 87

Aurukun EIS - Model calibration review (G1868J)

Hydraulic head in weathered Bulimba Formation following wet season rainfall

DATE	FIGURE No:
13/08/2021	**23**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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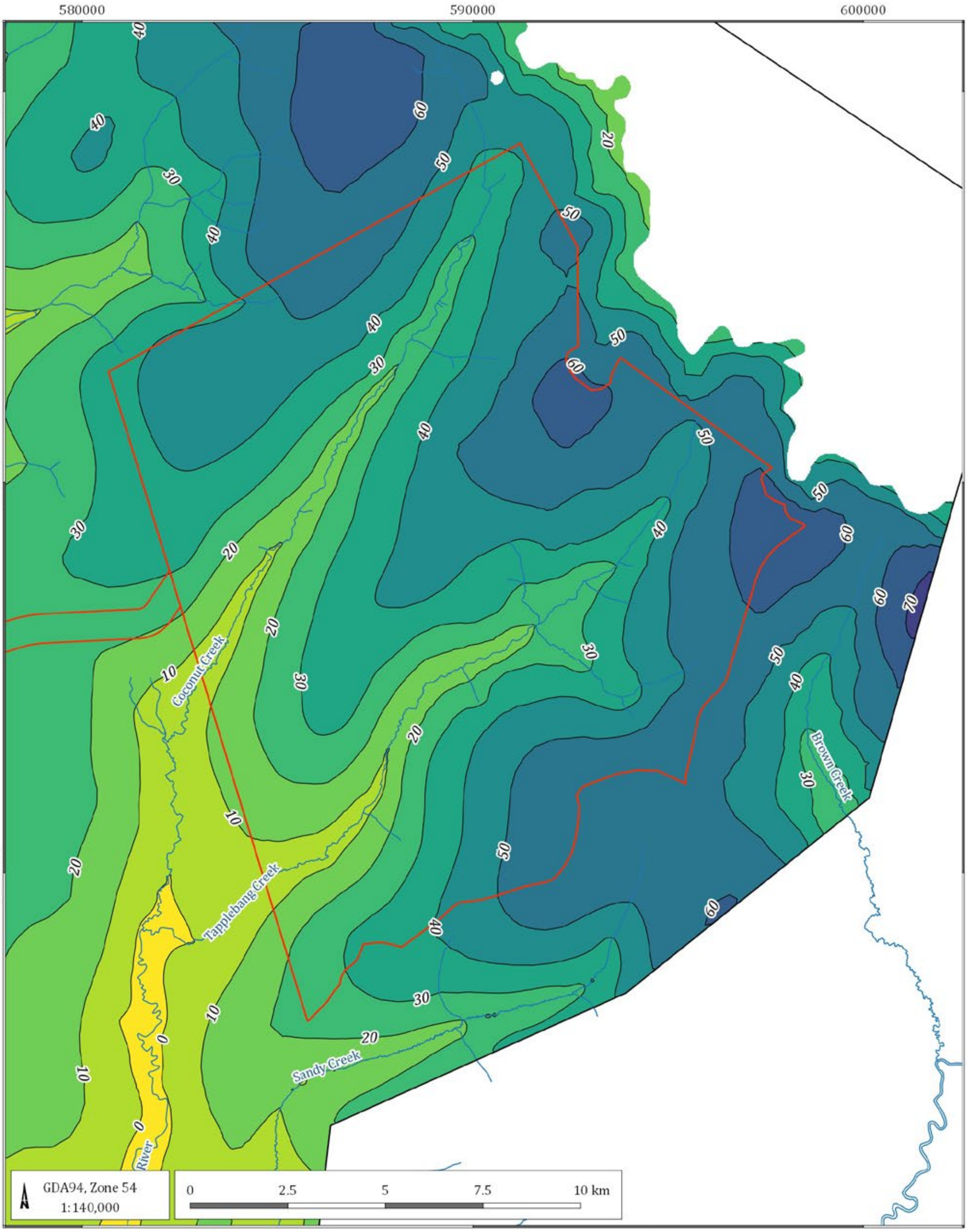

LEGEND

- Drainage feature
- Project site boundary
- Hydraulic head elevation contours
- Model domain boundary

Hydraulic head elevation (mAHD)

- 🟨 < 0
- 🟩 0 to < 10
- 🟩 10 to < 20
- 🟩 20 to < 30
- 🟩 30 to < 40
- 🟦 40 to < 50
- 🟦 50 to < 60
- 🟦 60 to < 70
- 🟪 70 to < 74

Aurukun EIS - Model calibration review (G1868J)

Hydraulic head in weathered Bulimba Formation following dry season

DATE
27/08/2021

FIGURE No:
24

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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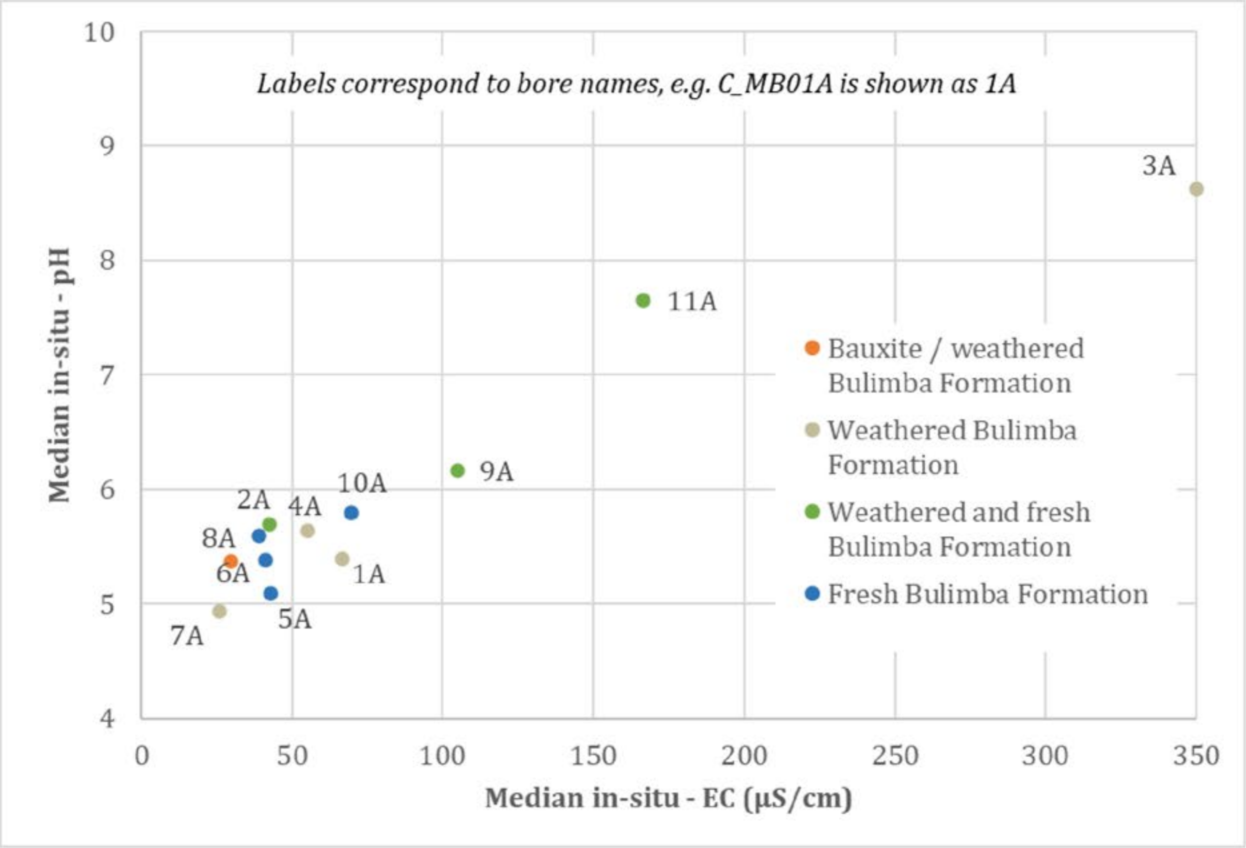


Figure 25 Relationship between groundwater pH and EC

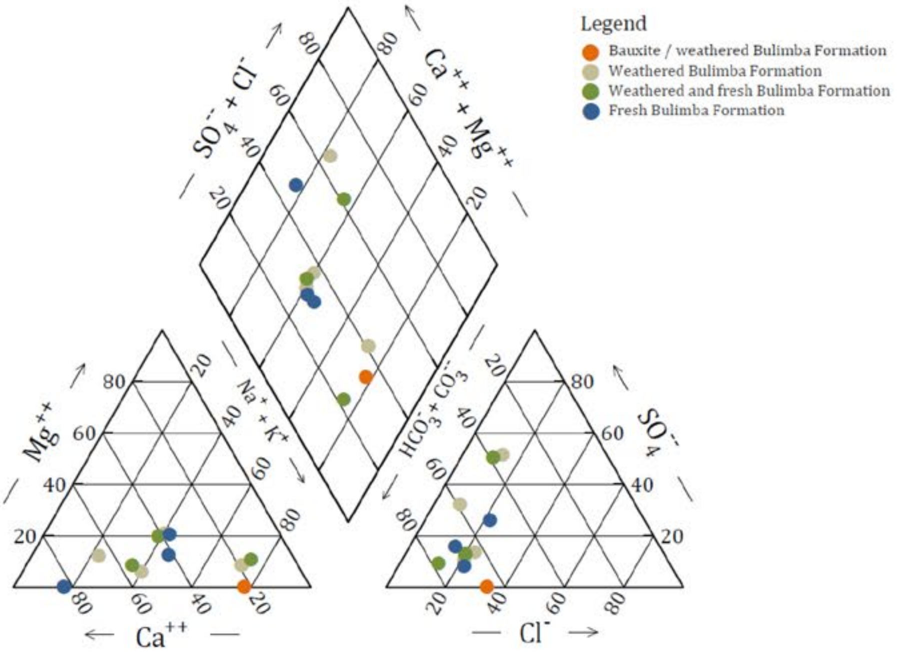
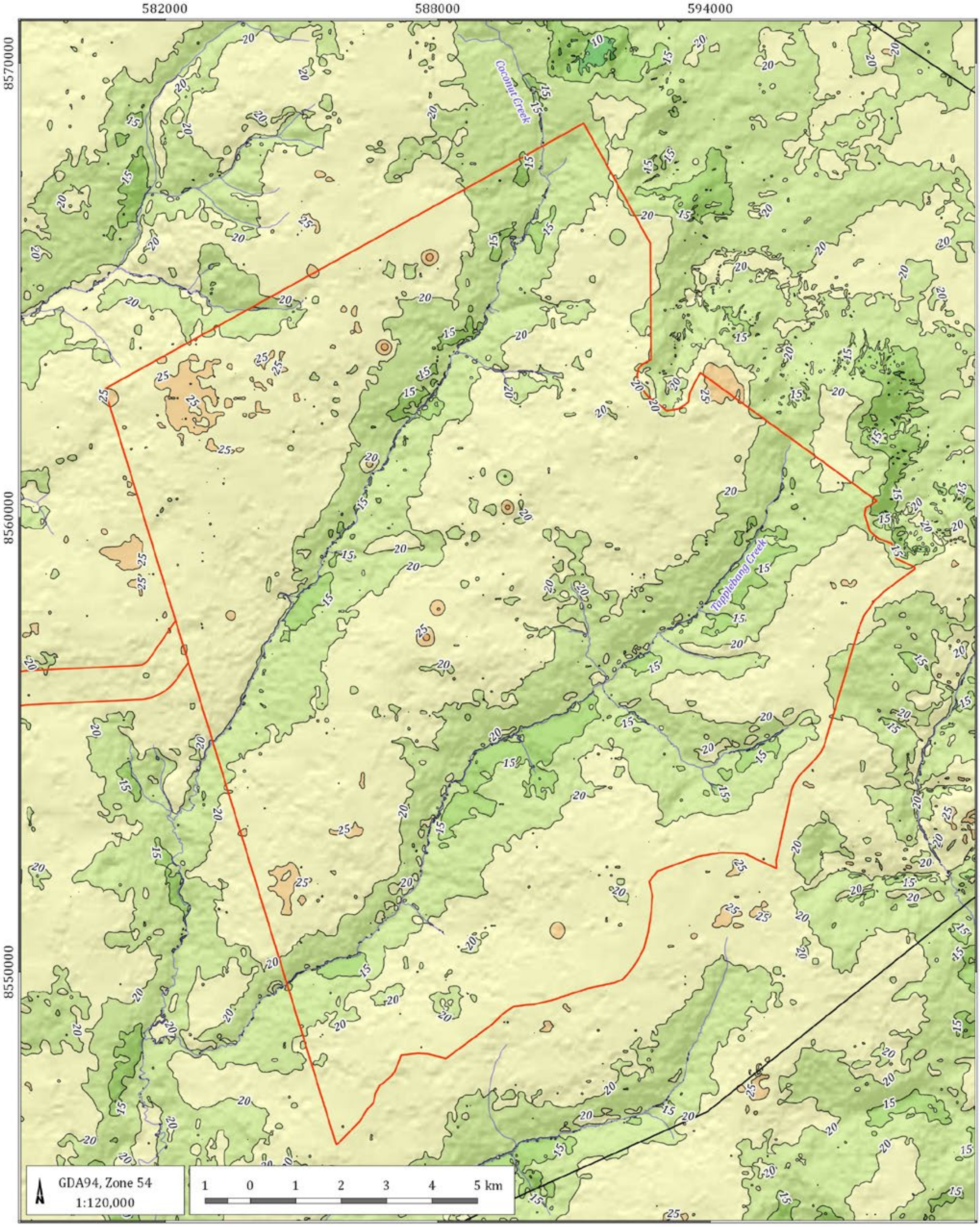


Figure 26 Piper diagram of groundwater ionic composition



LEGEND

- Drainage feature
- Project site boundary
- ☐ Model domain boundary

Depth to top of formation (meters below ground level)

- 🟩 0 to < 5
- 🟩 5 to < 10
- 🟩 10 to < 15
- 🟩 15 to < 20
- 🟨 20 to < 25
- 🟨 20 to < 25
- 🟧 25 to < 35
- Contour line

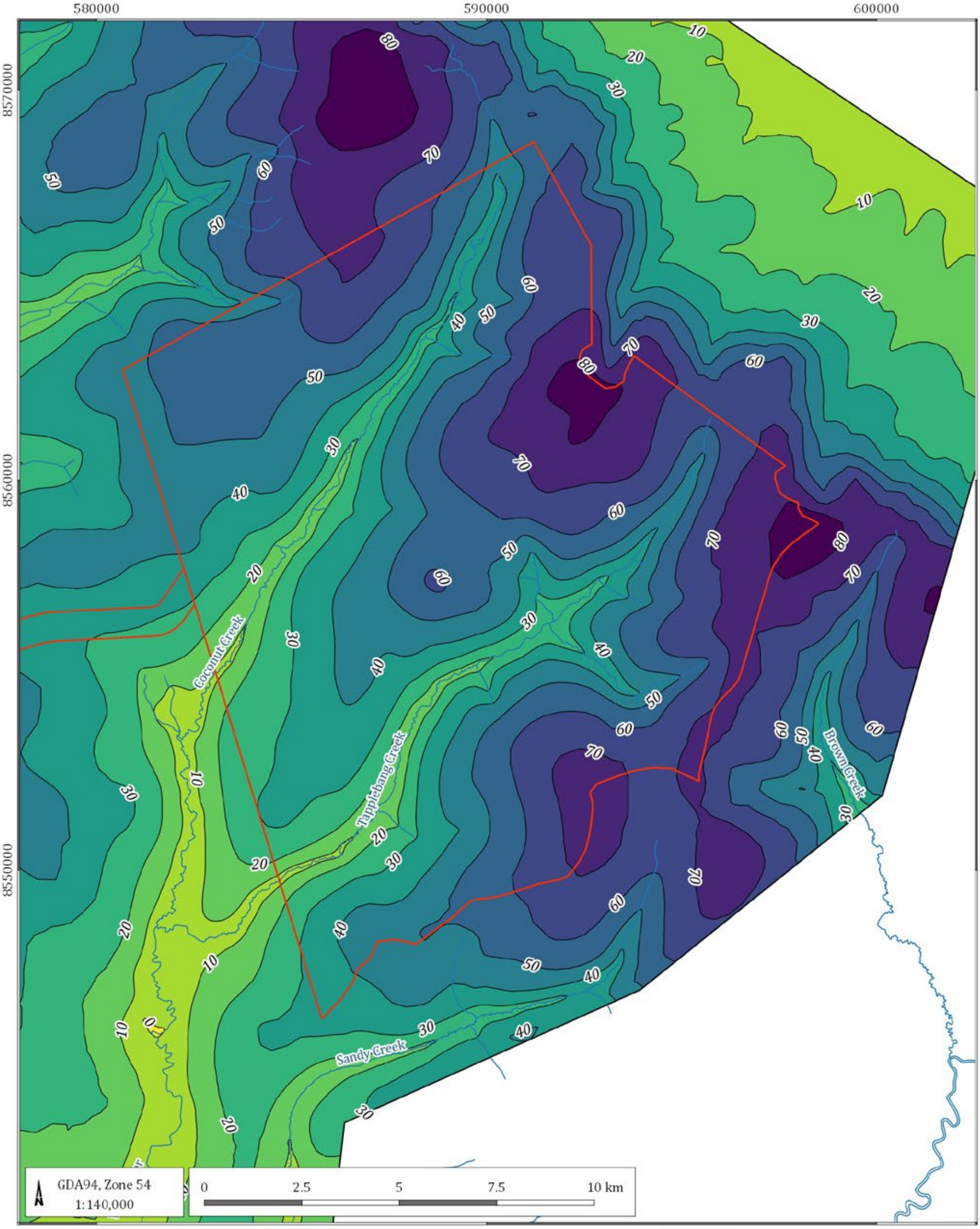
Aurukun EIS (G1868J)

Fresh Bulimba Formation Depth

DATE
16/08/2021

FIGURE No:
27

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\27.00_G1868J_Fresh Bulimba Formation Depth.qgs



LEGEND

- Drainage feature
- Hydraulic head elevation contours
- Project site boundary
- ▭ Model domain boundary

Hydraulic head elevation (mAHD)

- < 0
- 0 to < 10
- 10 to < 20
- 20 to < 30
- 30 to < 40
- 40 to < 50
- 50 to < 60
- 60 to < 70
- 70 to < 80
- 80 to < 90

Aurukun EIS - Model calibration review (G1868J)

Hydraulic head in the fresh Bulimba following wet season rainfall

AGE

DATE
13/08/2021

FIGURE No:
28

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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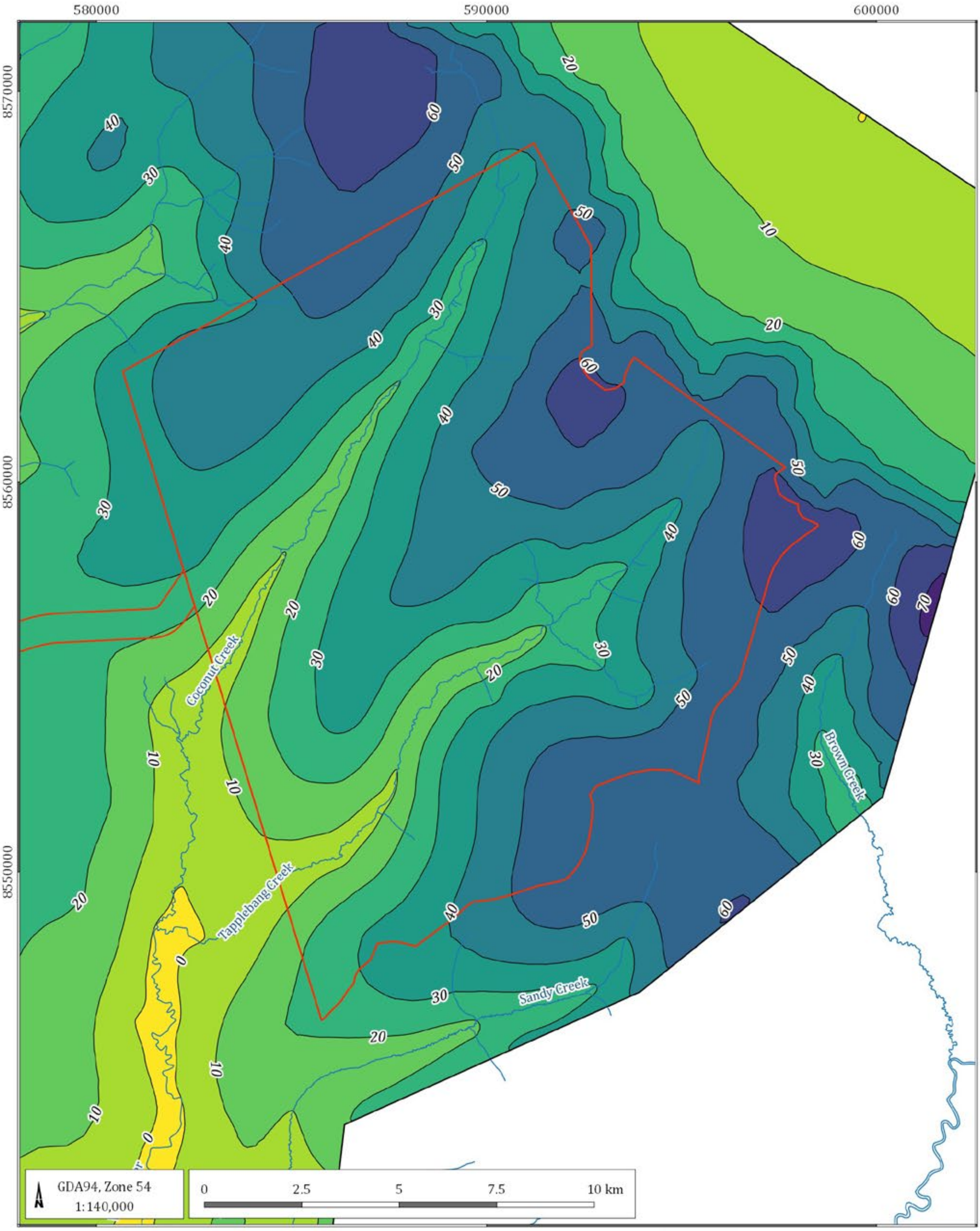

LEGEND

— Drainage feature

— Hydraulic head elevation contours

— Project site boundary

☐ Model domain boundary

Hydraulic head elevation (mAHD)

🟨 < 0

🟩 0 to < 10

🟩 10 to < 20

🟩 20 to < 30

🟩 30 to < 40

🟦 40 to < 50

🟦 50 to < 60

🟪 60 to < 70

🟪 70 to < 74

Aurukun EIS - Model calibration review (G1868J)

Hydraulic head in the fresh Bulimba following dry season

AGE

DATE 13/08/2021

FIGURE No: **29**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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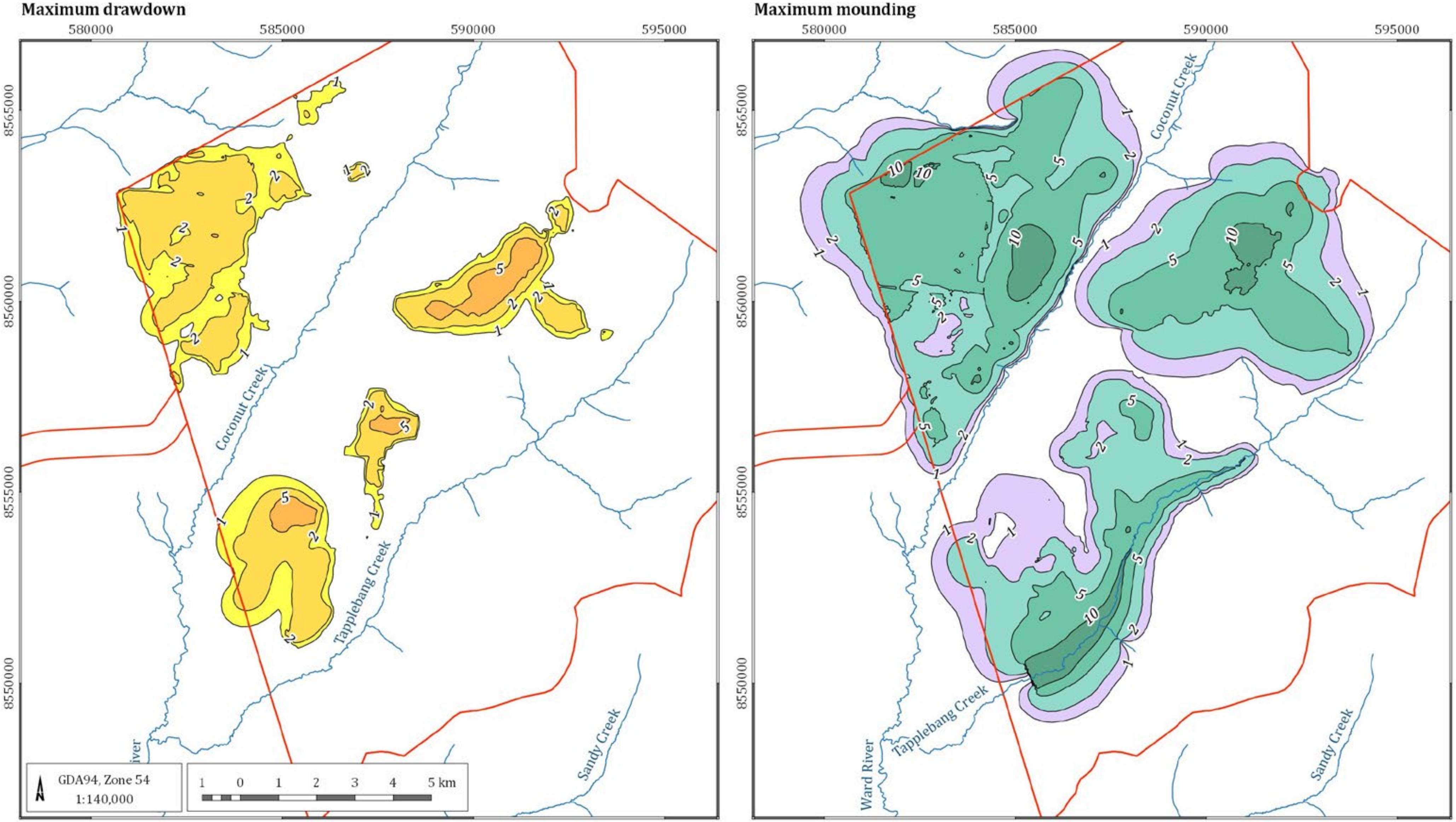


LEGEND

- Drainage feature
- Drawdown/mounding contour (m)
- Project site boundary

Drawdown (m)

- ⬜ 0 to < 1
- 🟨 1 to < 2
- 🟧 2 to < 5
- 🟧 5 to ≤ 8.5

Mounding (m)

- ⬜ 0 to < 1
- 🟪 1 to < 2
- 🟩 2 to < 5
- 🟩 5 to < 10
- 🟩 10 to ≤ 16.3

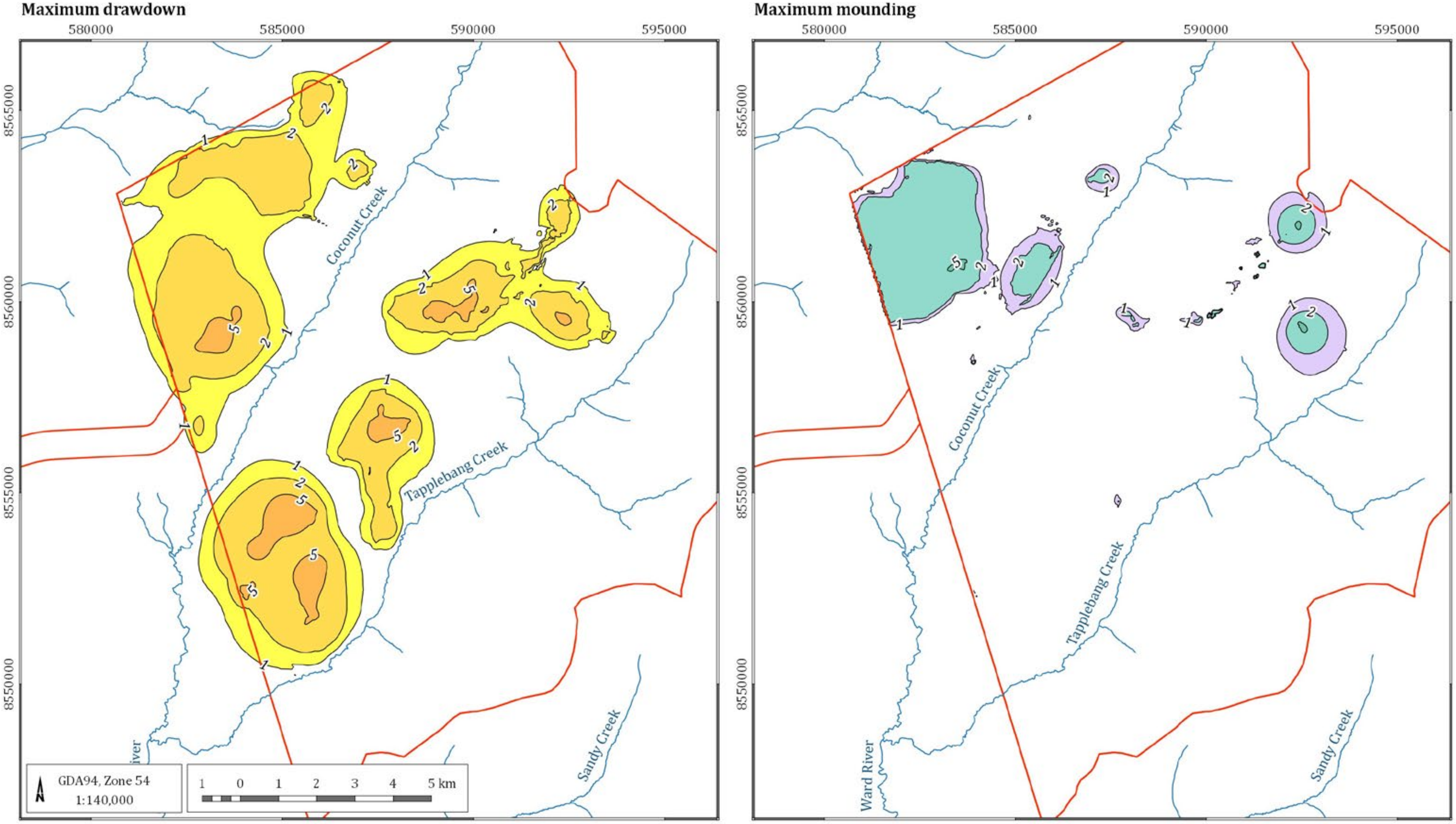
Aurukun EIS (G1868J)

Predicted maximum drawdown and mounding during mining operations

DATE
13/08/2021

FIGURE No:
30

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.; G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\30.00_G1868J_Predicted maximum drawdown and mounding during mining operations.qgs



LEGEND

— Drainage feature

— Drawdown/mounding contour (m)

— Project site boundary

Drawdown (m)	Mounding (m)
☐ 0 to < 1	☐ 0 to < 1
🟨 1 to < 2	🟪 1 to < 2
🟧 2 to < 5	🟩 2 to < 5
🟧 5 to ≤ 9.5	🟩 5 to ≤ 7

AGE

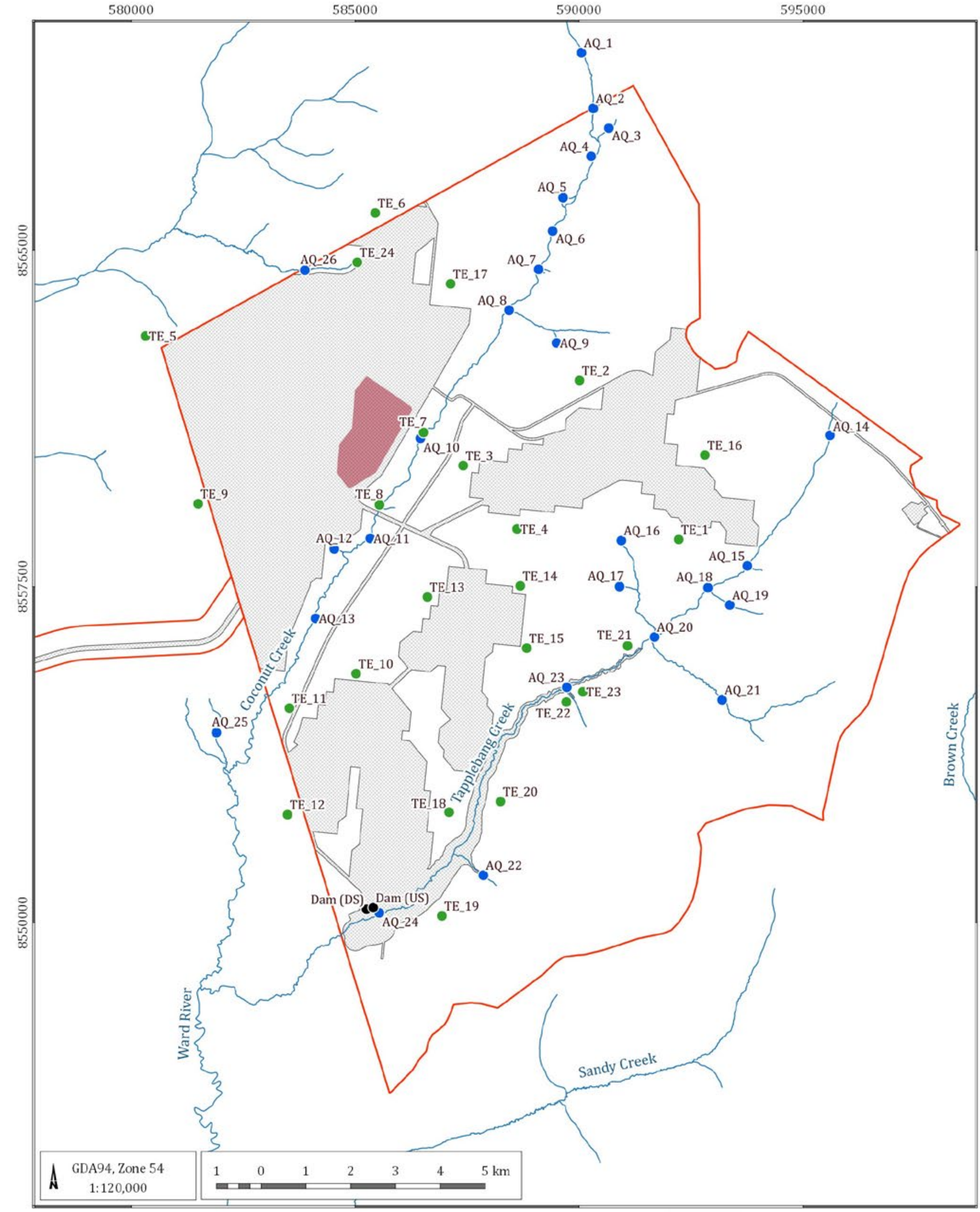
Aurukun EIS (G1868J)

Predicted maximum post mining drawdown and mounding

DATE
13/08/2021

FIGURE No:
31

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\30.00_G1868J_Predicted maximum drawdown and mounding during mining operations.qgs



LEGEND

- Drainage feature
- Project site boundary
- 🟥 Fines Containment Area
- ▨ Project disturbance footprint

Hydrograph sites

- ● Dam sites
- ● Aquatic habitat areas
- ● Sites around open cut mining areas and mine infrastructures

Aurukun EIS (G1868J)

Hydrograph Sites

AGE

DATE
13/08/2021

FIGURE No:
32

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\32.00_G1868J_Hydrograph sites.qgs

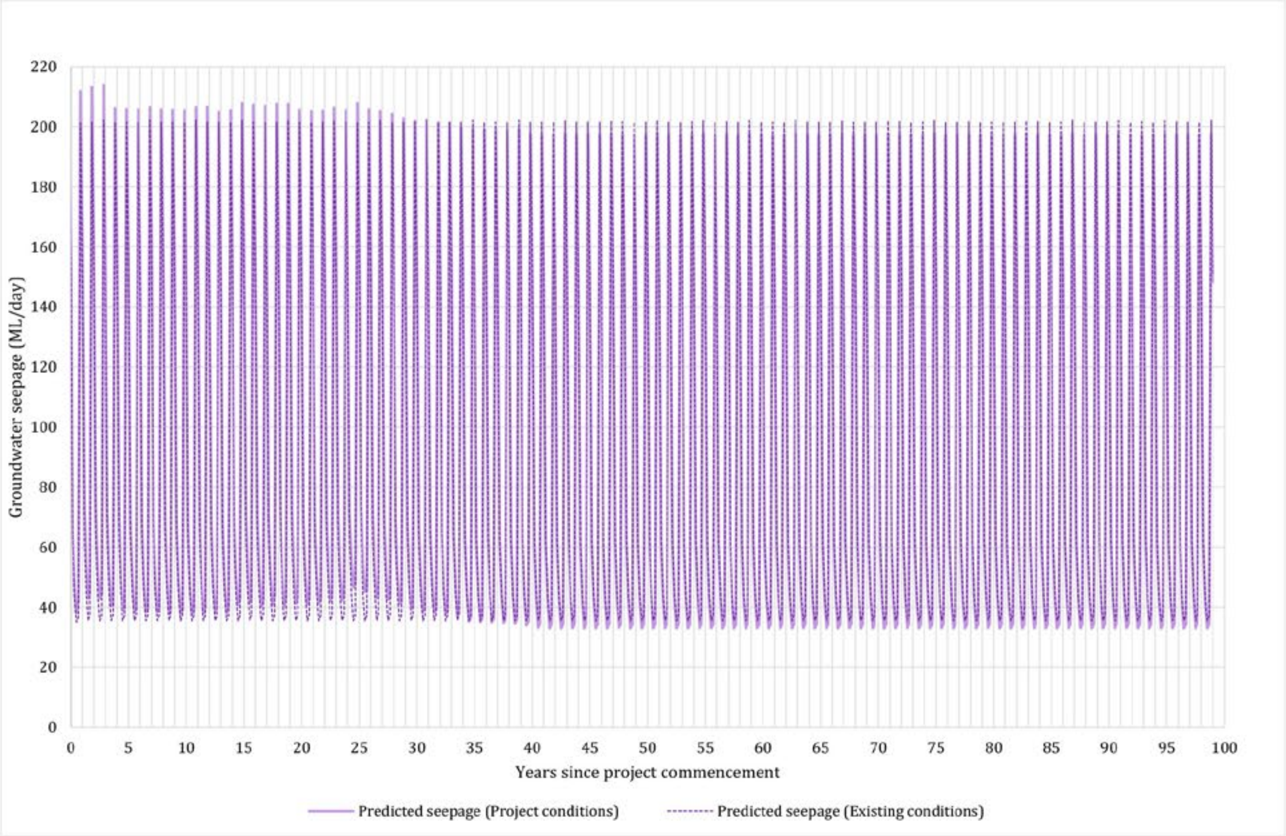


Figure 33 Predicted groundwater seepage to Coconut Creek

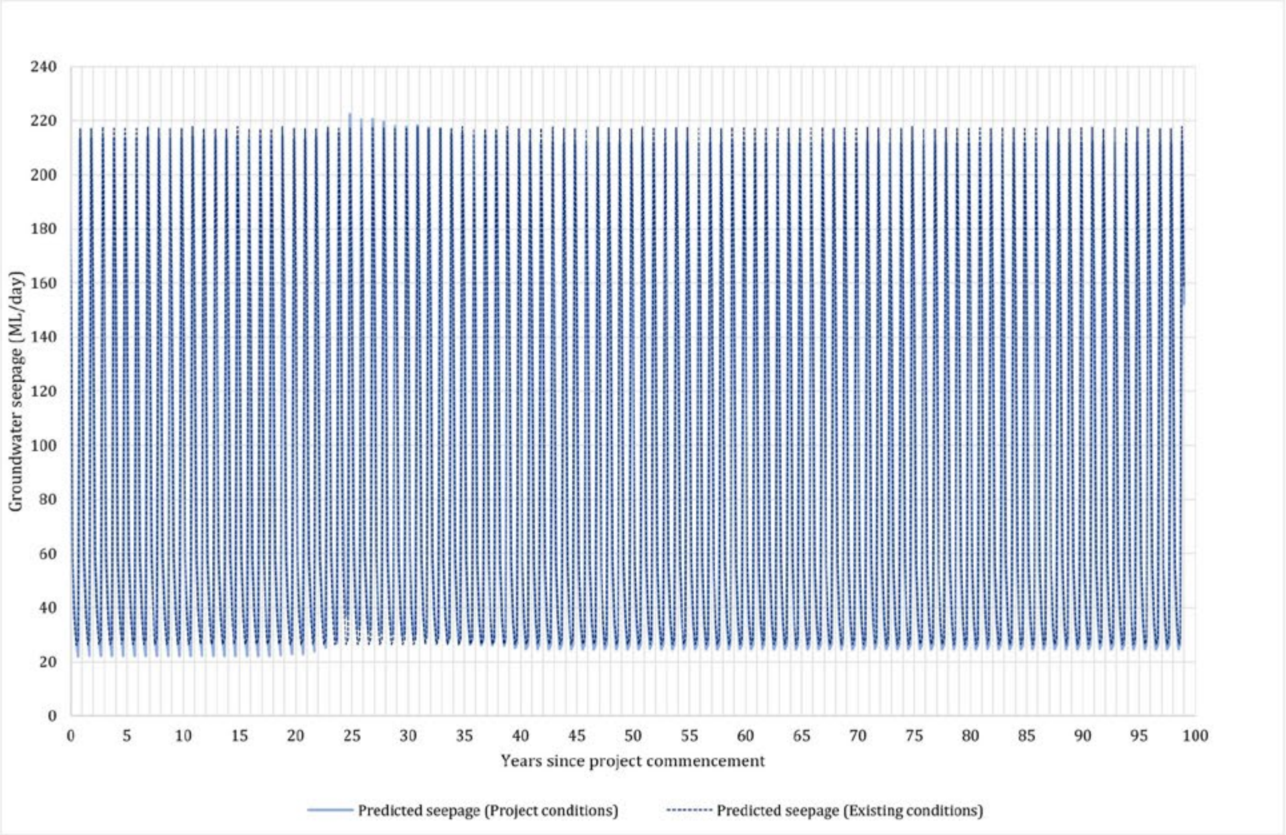


Figure 34 Predicted groundwater seepage to Tapplebang Creek

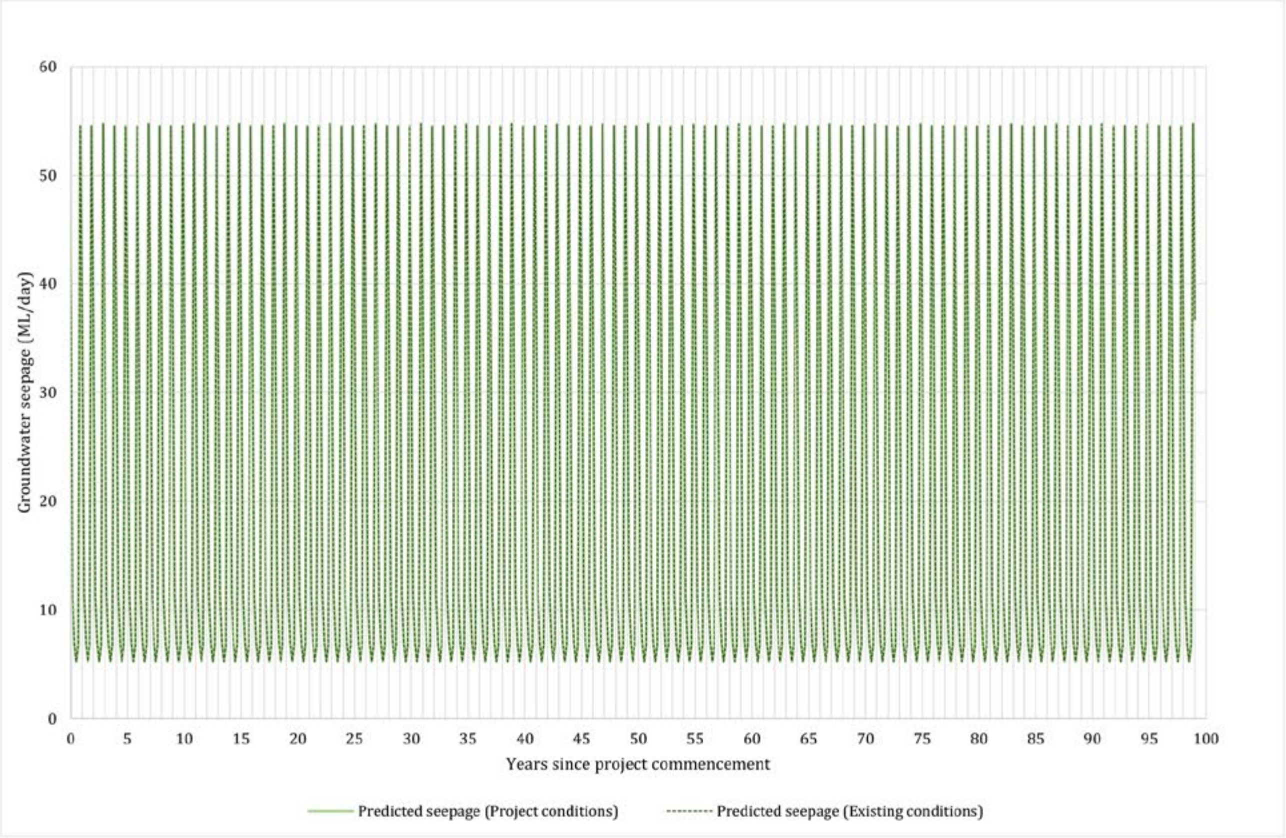


Figure 35 Predicted groundwater seepage to the Ward River

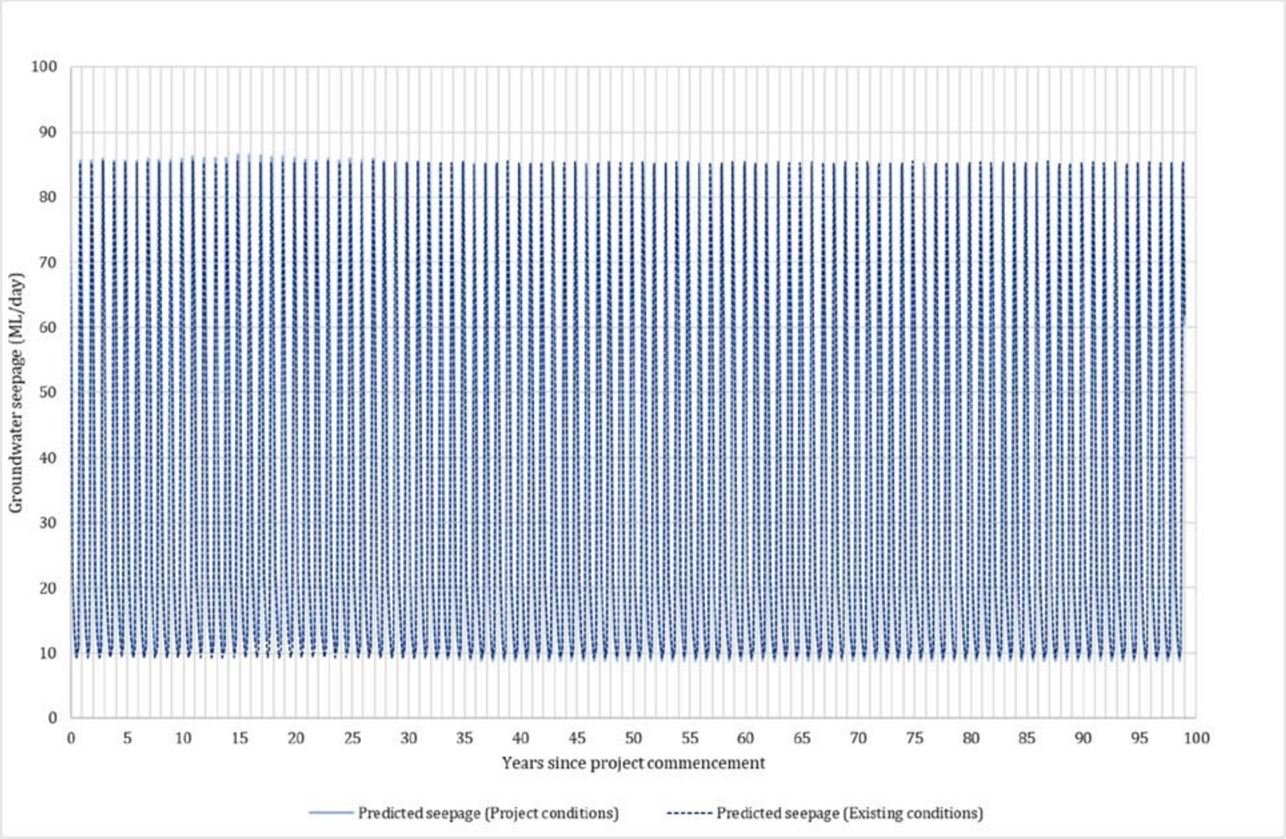


Figure 36 Predicted groundwater seepage to the Norman Creek catchment upstream of Arraw Dam

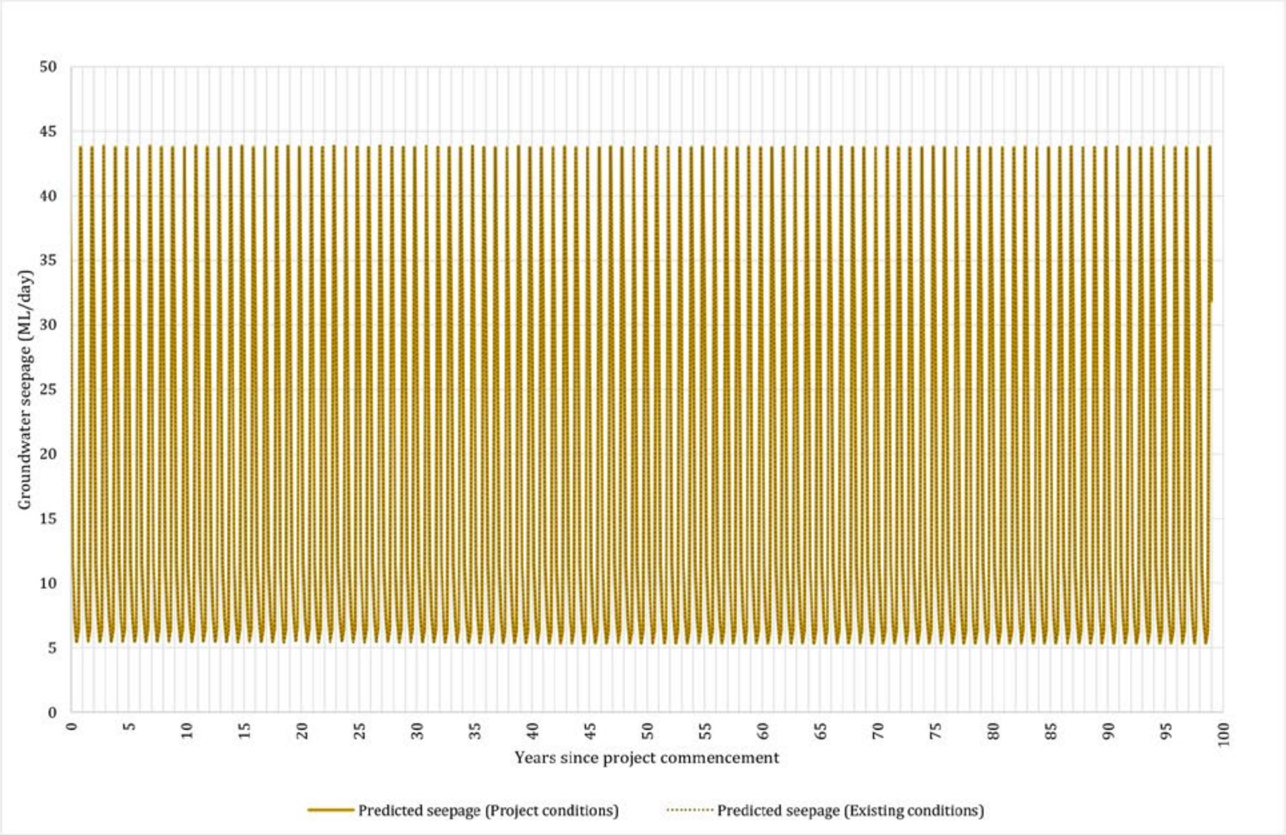


Figure 37 Predicted groundwater seepage to Coconut Creek upstream of AQ8

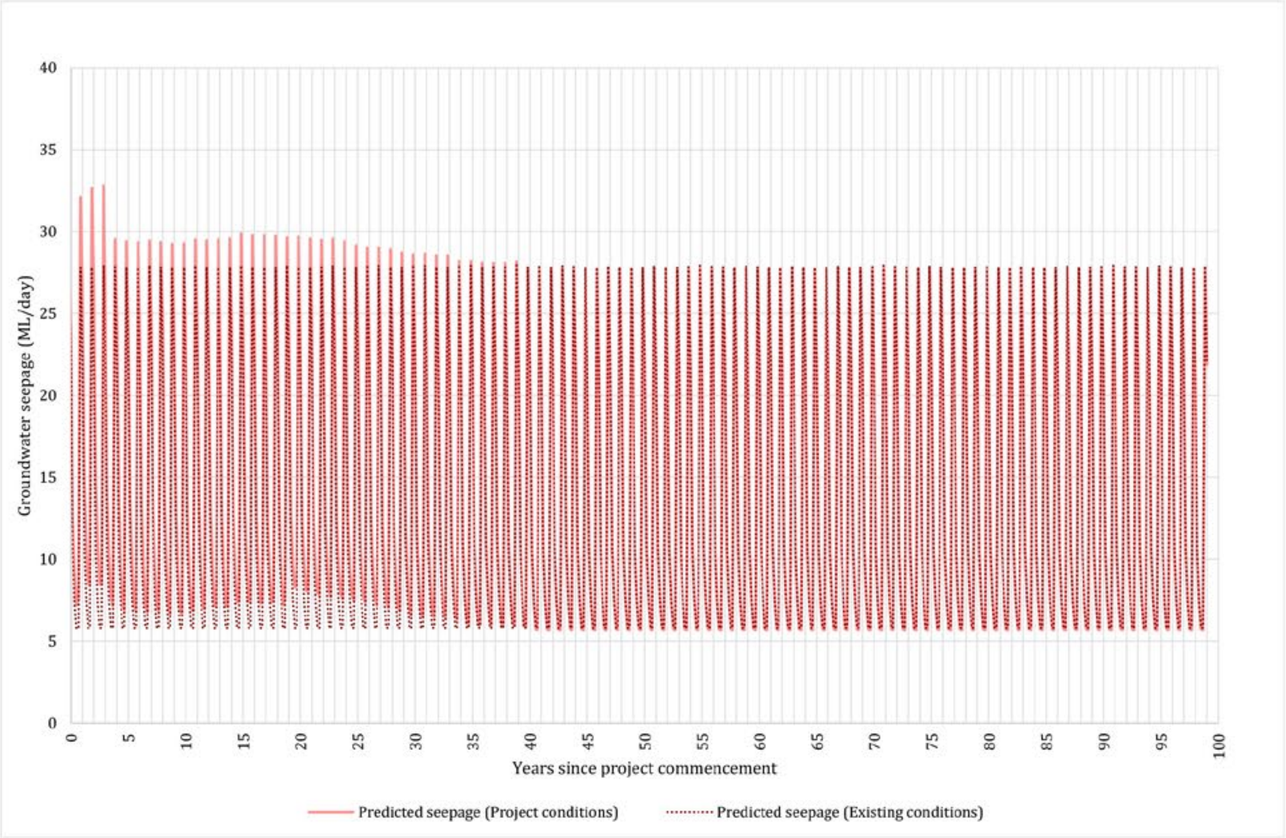


Figure 38 Predicted groundwater seepage to Coconut Creek between AQ8 and AQ10

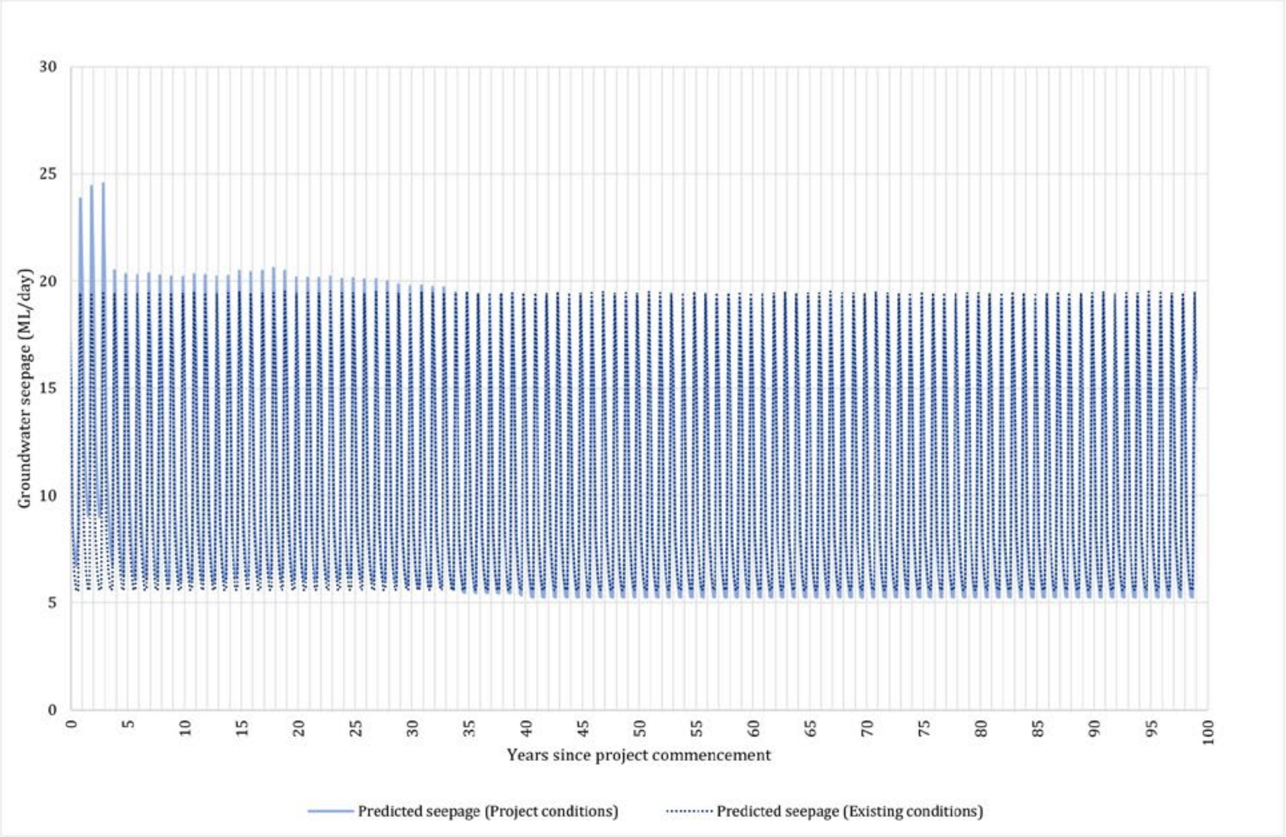


Figure 39 **Predicted groundwater seepage to Coconut Creek between AQ10 and AQ11**

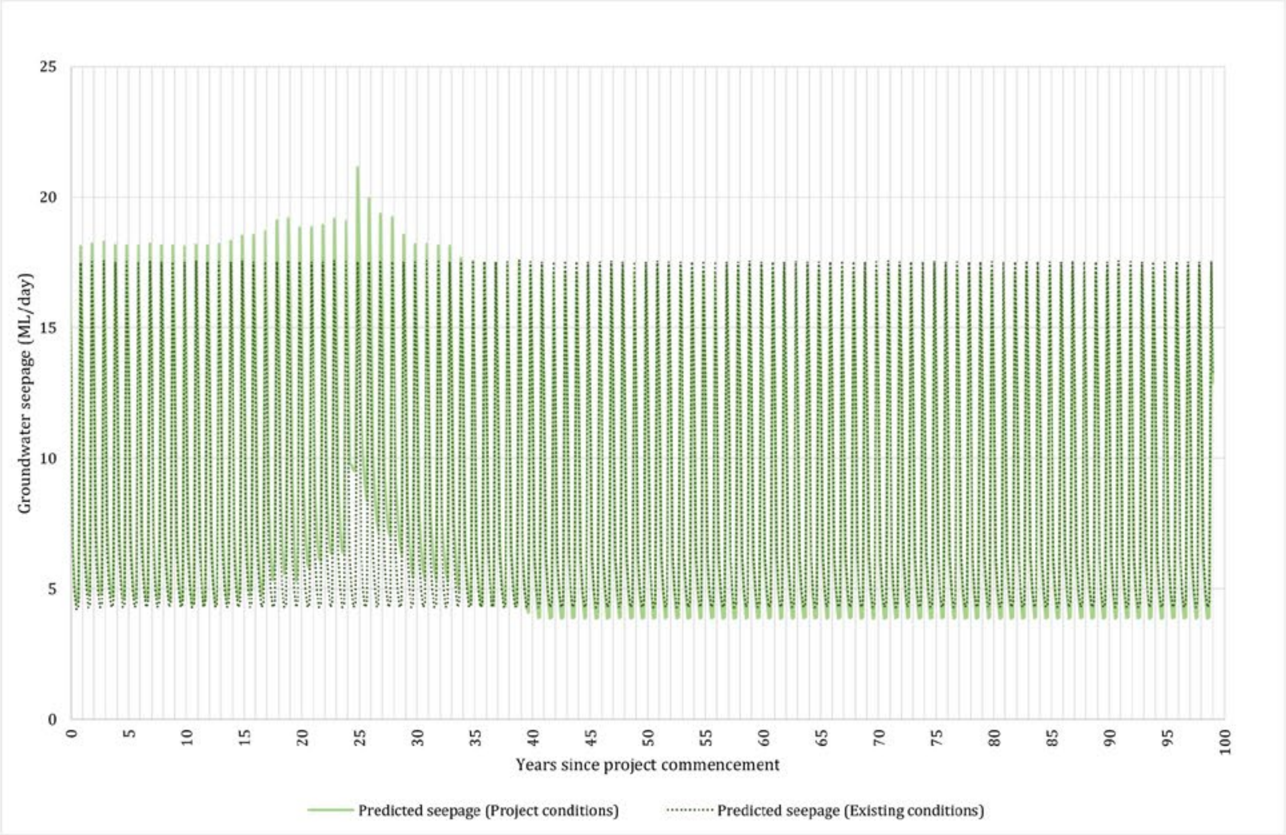


Figure 40 Predicted groundwater seepage to Coconut Creek between AQ11 and AQ13

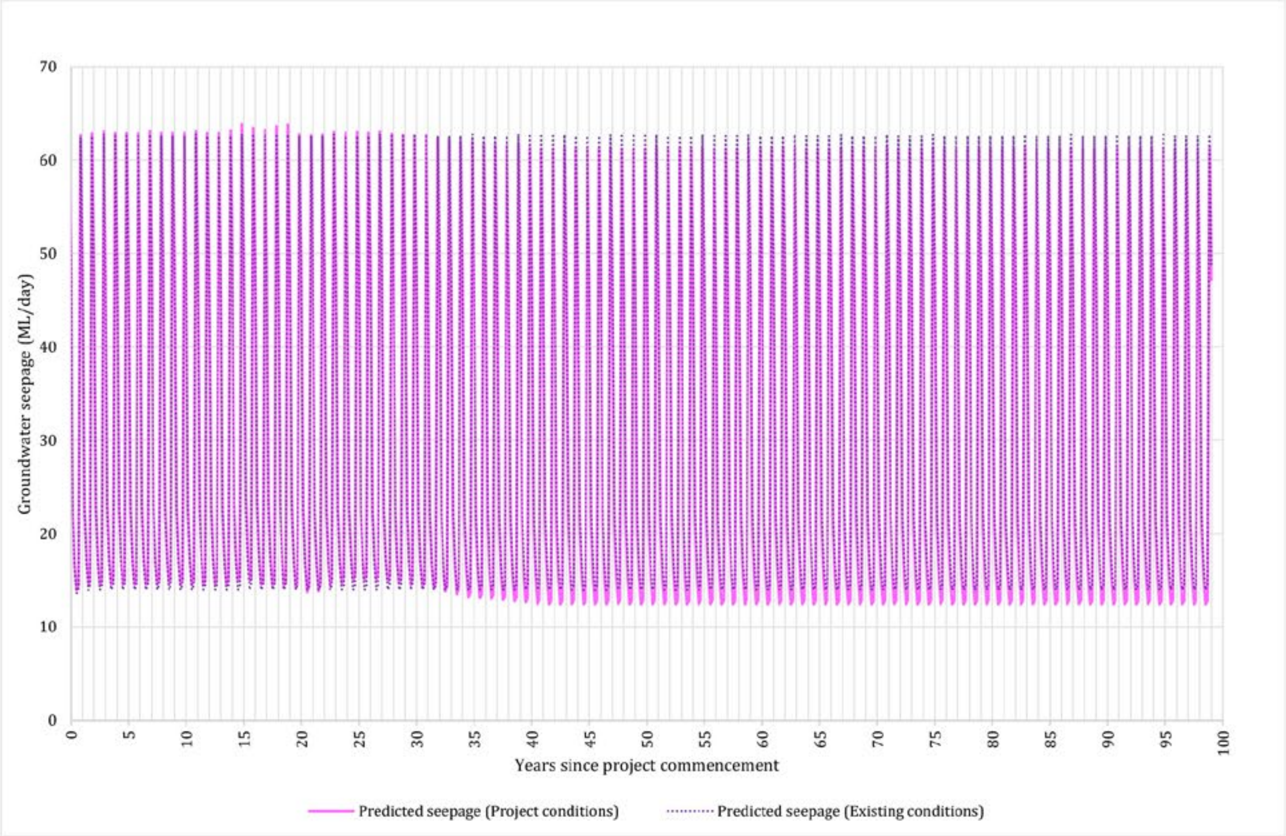


Figure 41 **Predicted groundwater seepage to Coconut Creek between AQ13 and the Ward River confluence**

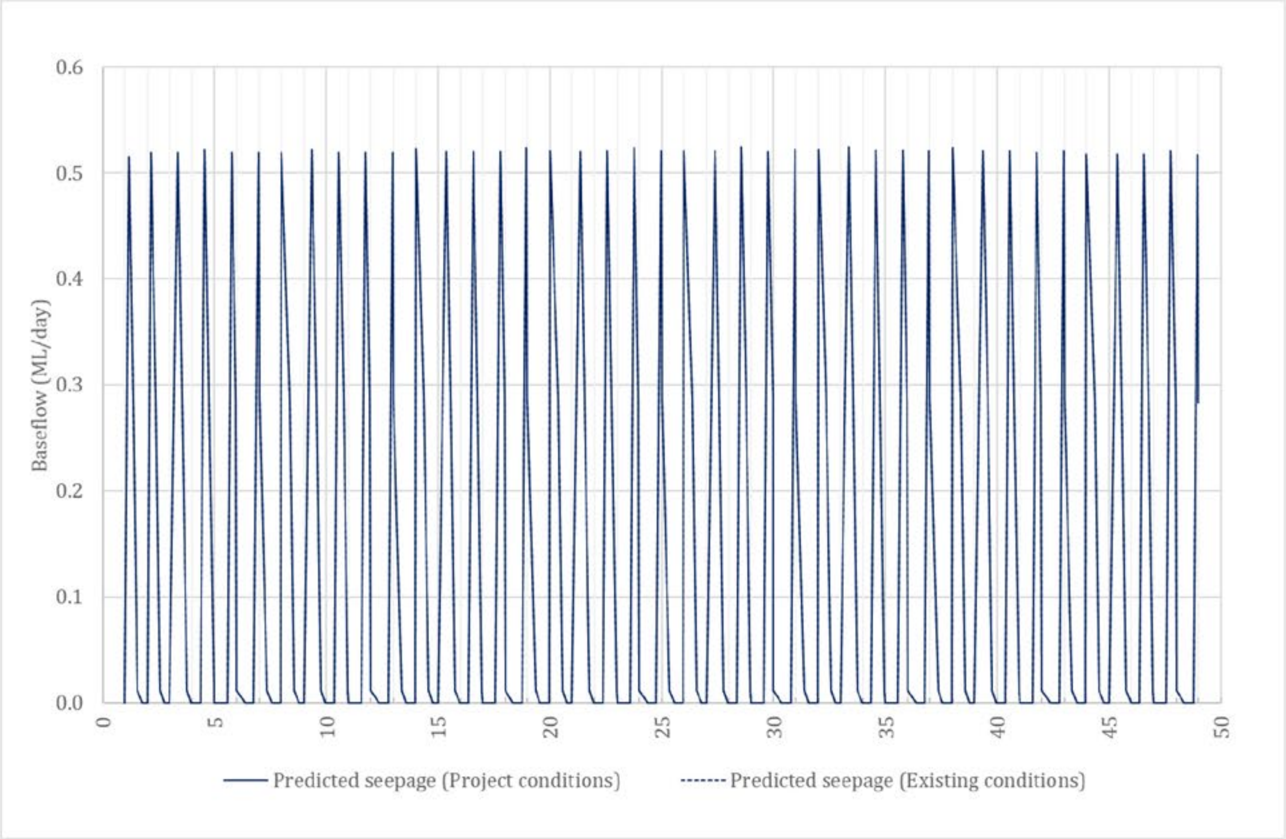
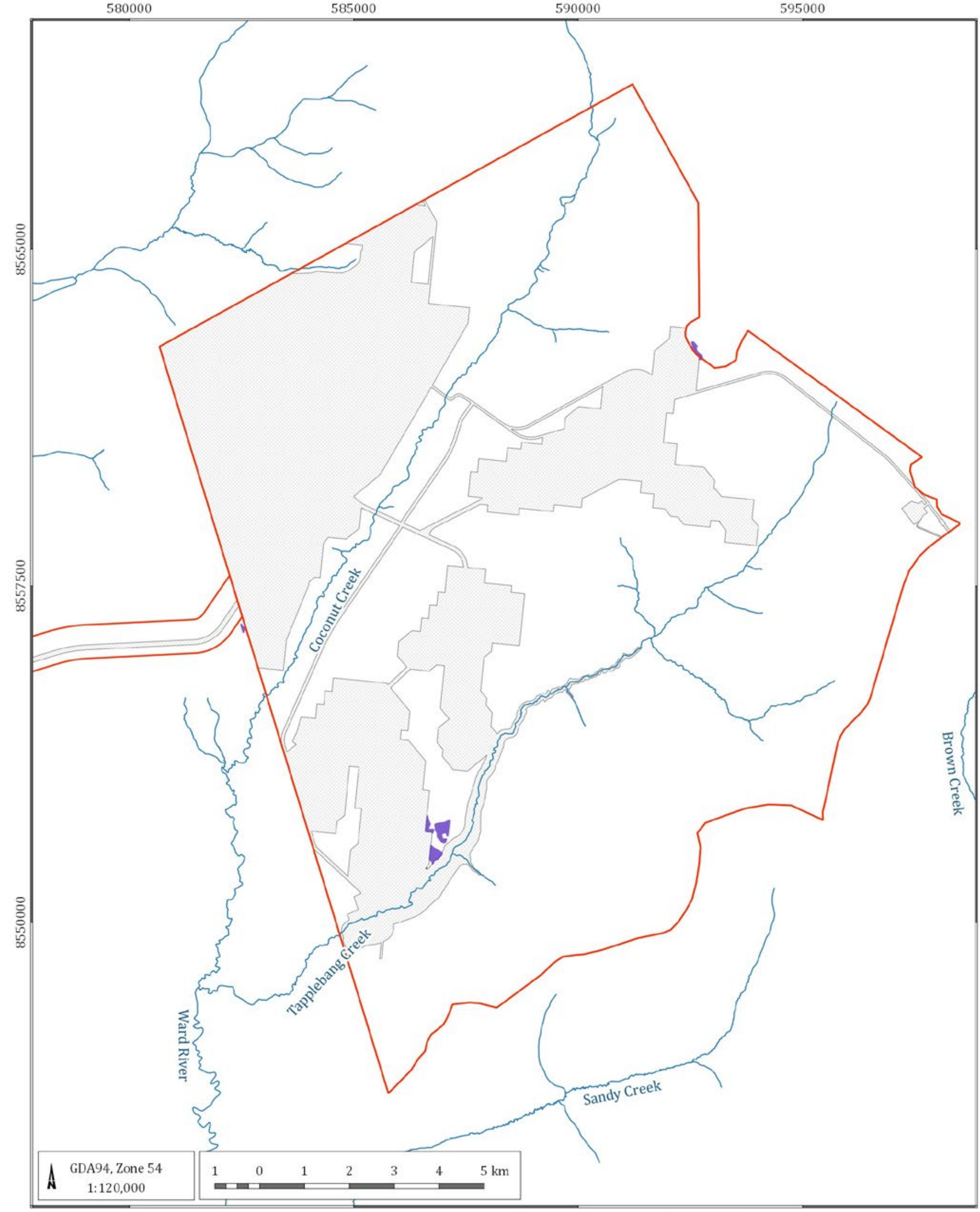


Figure 42 **Predicted groundwater seepage to Tapplebang Creek upstream of AQ17**



LEGEND

— Drainage feature

— Project site boundary

▇ Groundwater Dependent Ecosystems Potential Impact Area

▨ Project disturbance footprint

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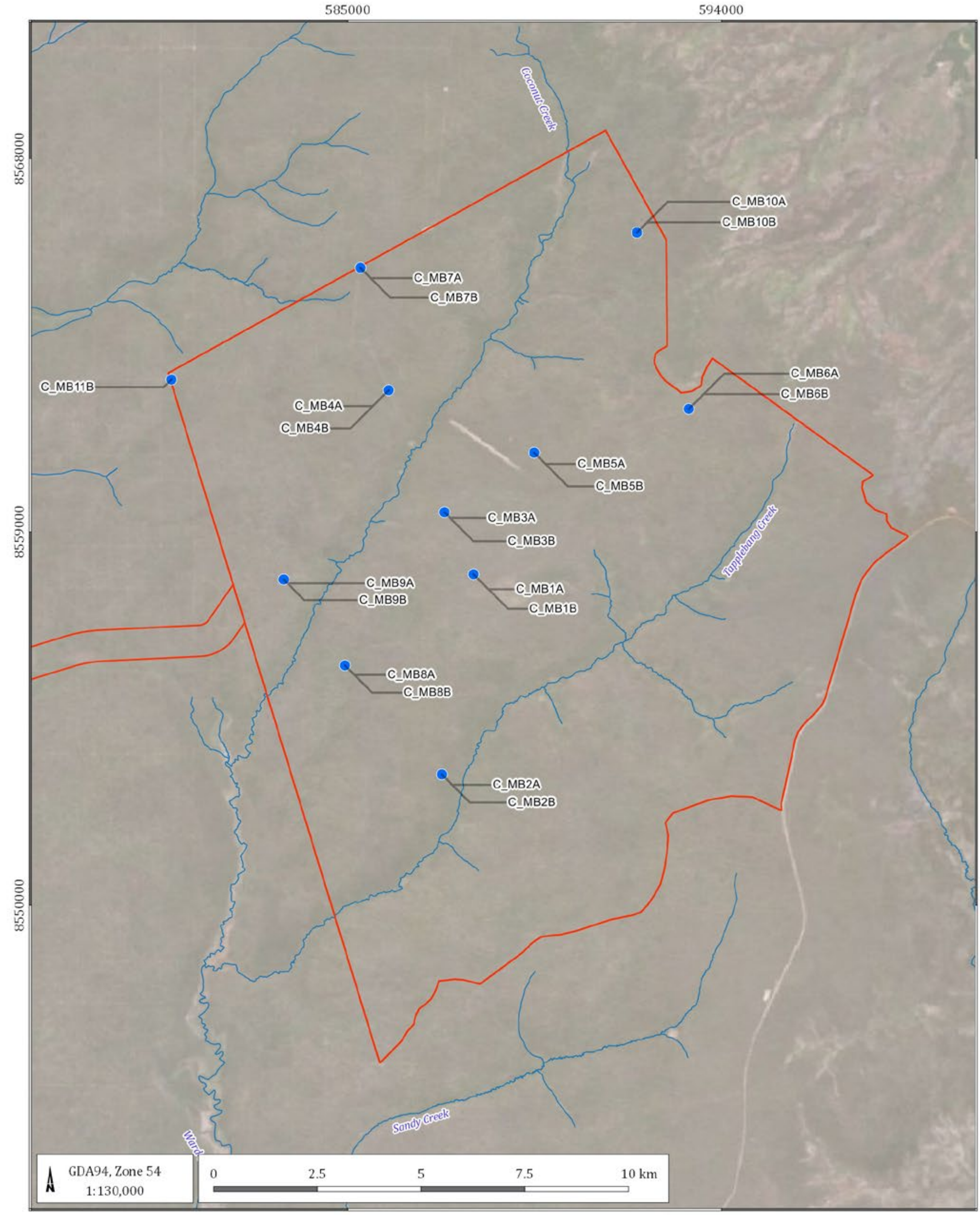
Groundwater Dependent Ecosystems Potential Impact Area

DATE 13/08/2021

FIGURE No: **43**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\43.00_G1868J_GDE potential impact area.qgs



LEGEND

- ● Proposed groundwater monitoring network bores
- — Drainage feature
- — Project site boundary

Aurukun EIS (G1868J)

Proposed groundwater monitoring network

DATE	FIGURE No:
14/08/2021	**44**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\44.00_G1868J_Proposed groundwater monitoring network_JKP_changes.qgs

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11 Abbreviations

AAET – actual areal evapotranspiration

AHD – Australian Height Datum

AGE – Australasian Groundwater and Environmental Consultants

BAP – Baseline Assessment Plan

BoM – Bureau of Meteorology

BTEXN – benzene toluene ethylene, xylene, and naphthalene

CLF – coastal loading facility

CRD – cumulative rainfall departure

CSIRO – Commonwealth Scientific and Industrial Research Organisation

DES – Department of Environment and Science

DRDMW – Department of Regional Development, Manufacturing and Water

DO – dissolved oxygen

EA – Environmental Authority

EC – electrical conductivity

EIS – Environmental Impact Statement

EP Act – *Environmental Protection Act 1994*

EPP Water – *Environmental Protection (Water and Wetland Biodiversity) Policy 2019*

FCA – fines containment area

Fm. - Formation

GAB – Great Artesian Basin

GABORA Water Plan – *Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017*

GDE – groundwater dependent ecosystem

GL – gigalitres

IECA – International Erosion Control Association

km - kilometres

m – metres

m/d – metres per day

mAHD – metres above Australian Height Datum

maGL – metres above ground level

mbGL – metres below ground level

mbTOC – metres below top of casing

Mdtpa – million dry tonnes per annum

MDL – mineral development licence

mg/L – milligram per litre

ML – mining lease

ML/a – megalitres per annum

ML/day – megalitres per day

mm - millimetres

mm/day – millimetres per day

mm/yr – millimetres per year

MR Act – *Mineral Resources Act 1989*

Mtpa – million tonnes per annum

NATA - National Association of Testing Authorities

ORP – oxidation–reduction potential

PRCP – Progressive Rehabilitation and Closure Plan

QWQG – *Queensland Water Quality Guidelines*

RMS – root mean square

ROM – run of mine

SEIS – Supplementary EIS

TDS – total dissolved solids

TPH – total petroleum hydrocarbons

TRH – total recoverable hydrocarbons

TCs – tropical cyclones

TSS – total suspended solids

µg/L – microgram per litre

µS/cm – microsiemens per centimetre

UWIR – Underground Water Impact Report

VOA – volatile organic acids

Water Act – *Queensland Water Act 2000*

WMS – water management system

WQO – water quality objective

% – percentage

12 Glossary

Anisotropy – flow reacts differently to stresses applied in different directions.

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, 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 that can store groundwater and also transmit it slowly from one aquifer to another. Typically, a geological formation of layers comprised of either clay bearing material or non-porous rock that restricts water flow from one aquifer to another.

Bauxite - alumina-rich sedimentary rock that mainly comprises the minerals gibbsite, boehmite and ferricrete.

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.

Falling head test - 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. (see also rising head test)

Hydraulic Conductivity – Also referred to as permeability, it is the 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.

Isotropy – uniform flow in all directions.

Kaolinite – a layered, aluminium rich, silicate clay mineral formed from the weathering of feldspar or other aluminium silicate minerals.

Laterite– iron and aluminium-oxide rich soil type derived from rocks weathering under strongly oxidizing and leaching conditions.

MODFLOW- USG – A commercial derivative of the standard MODFLOW code widely used for numerical groundwater modelling and presently considered the industry standard.

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.

Monitoring bores – Other terms which are often substituted include an 'observation well' or a 'piezometer.' Monitoring bores are drilled specifically to obtain information/data on groundwater and include bores to observe water levels, water quality or to intersect and monitor targeted contaminants.

Pisolite - Sedimentary rock made of pisoids, which are concretionary grains **-** which resemble ooids but are greater than 2 mm in diameter.

Porosity - The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment. Porosity is not necessarily directly proportional to permeability. Porosity is an important factor in understanding the stability of soils and rock.

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.

Rising head test - Rising 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. (see also Falling head test)

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 storage – indicates an aquifer's capacity to release water from or take water into storage when water level changes.

Specific yield – the volume of water released from storage by an unconfined aquifer per unit surface area of an aquifer during pumping.

Transmissivity - A measure of the rate at which water moves through an aquifer of unit width under a unit hydraulic gradient. Transmissivity is the average permeability multiplied by the saturated thickness.

Appendix A Groundwater Site Investigation

Aurukun Bauxite Project

Groundwater Site Investigation Report

A1 Introduction

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) was commissioned by Hansen Bailey on behalf of Glencore Bauxite Resources Pty Ltd to undertake a groundwater site investigation for the Aurukun Bauxite Project (the project). The groundwater site investigation was undertaken to inform a groundwater impact assessment. The groundwater impact assessment forms part of the Environmental Impact Statement (EIS) for the project. The project proponent is Glencore Bauxite Resources Pty Ltd, a wholly owned subsidiary of Glencore plc.

The groundwater site investigation included:

- Installation of a groundwater monitoring network in November 2017 that comprises 11 monitoring sites (C_MB1 to C_MB11, collectively called the 'C_MB series' bores in this report) located within the Mine Site (Figure A1). Each monitoring site comprises a pair of nested shallow and deep bores (i.e. 22 bores in total) (Figure A1). Shallow bores (with suffix 'B') typically collect data from the bauxite, and the deep bores (with suffix 'A') collect data from the underlying weathered and fresh Bulimba Formation.
- Installation of automatic transducers (dataloggers) in each monitoring bore to record continuous groundwater level data.
- Hydraulic permeability testing (rising/falling head tests) in each monitoring bore containing sufficient water.
- Initial and ongoing monthly manual groundwater level measurements from each monitoring bore.
- Initial and ongoing monthly collection and analysis of groundwater quality samples from each monitoring bore.
- An initial census of existing bores.

This report is an appendix to the EIS Groundwater Report. It provides a detailed description of the groundwater monitoring network and datalogger installation, initial groundwater quality sampling and testing, and hydraulic testing.

This report is structured as follows:

- Section A2 provides a detailed description of the groundwater site investigation, including the monitoring bore construction and installation details, bore development, initial groundwater levels and datalogger installation.
- Section A3 describes the lithologies encountered within each of the groundwater monitoring bore sites.
- Section A4 describes the permeability testing methods and results.
- Section A5 describes the groundwater quality sampling and analysis methods and water quality results.
- Section A6 describes the ongoing groundwater level data collection and results.
- Section A7 describes the initial bore census and findings.

The groundwater monitoring bore logs are presented in Appendix A1. Permeability test data analyses are presented in Appendices A2 and A3. Groundwater level data and hydrographs are presented in Appendix A4.

A2 Groundwater monitoring bore installation

A2.1 Drilling and construction

Strategic Drilling Services Pty Ltd installed 22 bores at 11 sites during November 2017.). Each monitoring site comprises a pair of nested shallow and deep bores (i.e. 22 bores in total) (Figure A1). Shallow bores (with suffix 'B') typically collect data from the bauxite, and the deep bores (with suffix 'A') collect data from the underlying weathered and fresh Bulimba Formation. Table A 1 provides construction details for all 22 groundwater monitoring bores, and Appendix A 1 presents the bore construction logs.

All monitoring bores were installed under the supervision of a Class 2 licensed groundwater bore driller (Michael Hanlon, Licence No. 3403). AGE provided technical guidance, including lithological logging and bore design. All holes were drilled and constructed according to the guidelines presented in the '*Minimum Construction Requirements for Water Bores in Australia* (NUDLC, 2012)'.

The groundwater monitoring bores were installed in a 150 mm diameter drillhole, drilled using the sonic drilling method. No drilling fluids were used. Each groundwater monitoring bore was constructed with 50 mm diameter, flush threaded, class 18 uPVC (with o-rings). The bore screen is machine slotted (1 mm aperture) class 18 uPVC. A filter pack of clean rounded to sub-rounded quartz gravel of 3 mm to 6 mm diameter was placed in the annulus to a height that covered the screened interval.

Bentonite pellets were placed above the filter gravel to form a seal to hydraulically isolate the screened section, and the remainder of the annulus was sealed by pumping a cement/bentonite (5%) grout via a tremie line. A monument style, lockable steel protector was cemented around the protruding casing at the surface.

Table A 1 Monitoring bore construction details

Monitoring bore ID	Screened stratigraphy	Easting[1]	Northing[1]	Ground surface elevation (mAHD)[2]	Drilled depth (mbGL)[3]	PVC stick up (maGL)[4]	Screen interval (mbGL)	Gravel pack interval (mbGL)	Standing water level at installation (mbGL)	Date of water level measurement
C_MB1A	weathered Bulimba Fm	588021.22	8557978.55	56.246	31.7	0.83	24.7 - 30.7	23.5 – 31.7	15.15	20 Nov 17
C_MB1B	bauxite	588023.33	8557973.73	56.246	3	0.83	2 - 3	1.5 - 3	dry	-
C_MB2A	Bulimba Fm/ weathered Bulimba Fm	587259.30	8553146.44	34.978	20	0.8	17 - 20	16 - 20	18.07	20 Nov 17
C_MB2B	weathered Bulimba Fm	587257.00	8553151.72	34.978	6	0.83	3 - 6	2 - 6	dry	-
C_MB3A	weathered Bulimba Fm	587322.87	8559469.89	42.998	24	0.85	21 - 24	20 - 24	10.81	20 Nov 17
C_MB3B	bauxite	587321.36	8559473.89	42.998	4	0.84	2 - 4	1.5 - 4	dry	-
C_MB4A	weathered Bulimba Fm	585977.99	8562414.19	49.611	21	0.81	18 - 21	17 - 21	16.35	18 Nov 17
C_MB4B	bauxite	585976.20	8562418.91	49.611	5	0.74	2 - 5	1.5 - 5	dry	-
C_MB5A	Bulimba Fm	589476.65	8560908.65	70.107	17	0.88	14 - 17	13 - 17	dry	-
C_MB5B	weathered Bulimba Fm	589481.79	8560909.56	70.107	2	0.83	0.5 - 2	0.3 - 2	dry	-
C_MB6A	Bulimba Fm	593215.39	8561963.52	83.172	23.5	0.85	20.5 - 23.5	19.5 - 23.5	15.65	18 Nov 17
C_MB6B	weathered Bulimba Fm/ bauxite	593211.03	8561962.64	83.172	4	0.84	1 - 4	0.6 - 4	dry	-
C_MB7A	weathered Bulimba Fm	585301.69	8565366.05	67.358	32	0.54	24.5 - 27.5	23.5 – 27.5	9.9	18 Nov 17

Monitoring bore ID	Screened stratigraphy	Easting[1]	Northing[1]	Ground surface elevation (mAHD)[2]	Drilled depth (mbGL)[3]	PVC stick up (maGL)[4]	Screen interval (mbGL)	Gravel pack interval (mbGL)	Standing water level at installation (mbGL)	Date of water level measurement
C_MB7B	weathered Bulimba Fm/ bauxite	585304.31	8565369.91	67.358	6	0.6	3 - 6	2 - 6	dry	-
C_MB8A	Bulimba Fm	584923.33	8555777.13	38.499	20.8	0.81	17.8 - 20.8	16.8 - 20.8	15.20	20 Nov 17
C_MB8B	weathered Bulimba Fm	584926.04	8555780.99	38.499	6	0.79	3 - 6	2 - 6	dry	-
C_MB9A	Bulimba Fm/ weathered Bulimba Fm	583450.05	8557847.70	34.932	24	0.83	21.0 – 24.0	20.8 - 24	20.47	20 Nov 17
C_MB9B	weathered Bulimba Fm	583450.11	8557842.79	34.932	6	0.85	3 - 6	2.1 - 6	dry	-
C_MB10A	Bulimba Fm	591967.96	8566214.21	71.800	21	0.82	17.0 - 21.0	17 - 21	14.14	19 Nov 17
C_MB10B	bauxite	591967.11	8566217.97	71.800	4	0.84	1.0 - 4.0	0.6 - 4.0	dry	19 Nov 17
C_MB11A*	weathered Bulimba Fm/ Bulimba Fm	580747.03	8562671.94	49.070	33	0.83	30.0 - 33.0	28.9 – 33	25.57	18 Nov 17
C_MB11B	bauxite	580751.21	8562675.58	49.070	6	0.84	3.0 - 6.0	2 – 6	dry	18 Nov 17

Notes: *[1] Coordinates are in GDA94, Zone 54.*

[2]mAHD = metres Australian Height Datum.

[3]mbGL = metres below ground level.

[4]maGL = metres above ground level.

Bores noted as "dry" for water level were dry at the time of development.

A2.2 Bore development

The monitoring bores were developed with air to remove drilling fines and enhance the hydraulic connectivity with the surrounding aquifer. Generally, the bores were developed for between one and four hours, until the field water quality parameters (for pH and electrical conductivity [EC]) had stabilised. However, several bores did not yield sufficient flow to develop in a single visit. These sites were airlifted up to three times to ensure the bores were developed to a suitable standard for their use. Bores which were dry at the time of drilling were not developed.

A2.3 Groundwater levels and logger installations

Groundwater levels in all groundwater monitoring bores were measured manually using a water level dipper between 18 November and 20 November 2017, and the results are summarised in Table A 2.

Solinst Levelogger Edge Model 3001 (M30) data loggers were installed in all monitoring bores. The loggers were programmed to start recording on 18 November 2017 at 12 pm, recording at four hourly intervals. Table A 2 contains data logger installation details.

Table A 2 Data logger details

Monitoring bore ID	Serial number	Logger depth (mbGL)	Recording interval
C_MB1A	0052079643	16.43	4 hourly
C_MB1B	0052080596	3.59	4 hourly
C_MB2A	0052080605	21.59	4 hourly
C_MB2B	0052079637	5.47	4 hourly
C_MB3A	0052080599	18.06	4 hourly
C_MB3B	0052080607	3.58	4 hourly
C_MB4A	0052080630	20.68	4 hourly
C_MB4B	0052079667	5.98	4 hourly
C_MB5A	0052079645	17	4 hourly
C_MB5B	0052079652	1.45	4 hourly
C_MB6A	0052079666	20.63	4 hourly
C_MB6B	0052079689	4.69	4 hourly
C_MB7A	0052079650	21.05	4 hourly
C_MB7B	0052079669	6.81	4 hourly
C_MB8A	0052079688	17.7	4 hourly
C_MB8B	0052079660	5.65	4 hourly
C_MB9A	0052079640	21.38	4 hourly
C_MB9B	0052079658	6.41	4 hourly
C_MB10A	0052079641	20.88	4 hourly
C_MB10B	0052079672	4.69	4 hourly
C_MB11A[1]	0052079651	27.99	4 hourly
C_MB11B	0052079654	5.59	4 hourly

Note: *mbGL – metres below ground level*

A3 Lithology

Appendix A 1 provides the bore lithology logs with descriptions of all the formations encountered in each bore hole. The units present in these logs (in descending stratigraphic order) are:

- Bauxite ore;
- Weathered Bulimba Formation sediments;
- Fresh (i.e. unweathered) Bulimba Formation sediments; and

The bore logs show that:

- The bauxite ore is typically covered by a thin veneer of topsoil and subsoil that is up to approximately 1 m thick.
- The bauxite ore is an alumina-rich sedimentary deposit that mainly comprises the minerals gibbsite, boehmite and ferricrete. The bauxite ore texture grades from loose, granular pisolite to cemented, massive pisolite. The bauxite ore is widely distributed over the Mine Site. Where present, the bauxite ore is typically located at, or within 1 m of, the ground surface. The bauxite ore is at least 1 m thick, where present.
- The weathered Bulimba Formation comprises kaolinite and clay-rich sediments (silty clay, sandy clay). The full laterite (tropical weathering) profile includes the upper bauxite ore and the underlying weathered Bulimba Formation; this laterite profile ranges between 14 m and 30 m in thickness.
- The fresh Bulimba Formation is typically siltstone, with minor clayey quartzose and feldspathic sandstone.

A4 Permeability data

Permeability testing to obtain the hydraulic conductivity of the strata was conducted on all groundwater monitoring bores, excluding dry bores, or those with very low water levels that prevented the collection of reliable test results. Permeability testing was conducted using two methods: a falling head test immediately after installation and a rising head test after purging for regular sampling.

The falling head test involved dropping a solid ‘slug’ into the column of water, which resulted in an instantaneous rise in the water level in the bore. As the water level recovered to equilibrium, the falling head was measured at regular intervals, using a pressure transducer. Each falling head test was conducted over a minimum of 30 minutes duration. During each falling head test, the water level was also measured manually using an electric water level dipper. The data obtained from the pressure transducers was analysed using Aquifer Test 2011.1 software (Schlumberger Water Services, 2011) using the unconfined aquifer method for falling head tests from Bouwer and Rice (1976).

For the rising head test, data recorded in the pressure transducer during and after sampling was analysed. Prior to groundwater quality sampling, all bores were purged, causing a drawdown in the water level in the bore. The influx of groundwater to the bore after purging caused a rise in the head level, at a rate commensurate with the aquifer permeability. The data obtained from the pressure transducers was analysed using Aquifer Test 2011.1 software using the unconfined aquifer method for rising head tests from Bouwer and Rice (1976).

The hydraulic test results are shown in Table A 3 and Figure A3. The graphical analyses of falling head tests for each groundwater monitoring bore are presented in Appendix A 2; and the graphical analyses of recovery data (rising head tests) for each groundwater monitoring bore are presented in Appendix A 2.

Table A 3 Project hydraulic test results: weathered Bulimba Formation

Monitoring bore ID	Screen lithology	Screen stratigraphy	Hydraulic conductivity from in-situ permeability tests (m/day)*	Hydraulic conductivity from recovery data (m/day)**
C_MB1A	silty clay/ clay	weathered Bulimba Fm	0.01	0.0021
C_MB2A	siltstone/ silty clay	Bulimba Fm/ weathered Bulimba Fm	-	0.0021
C_MB3A	clay/ sandy clay	weathered Bulimba Fm	0.017 (early time data) 0.002 (late time data)	0.0017
C_MB4A	clay	weathered Bulimba Fm	0.013	0.0037
C_MB6A	siltstone	Bulimba Fm	0.06	0.0082
C_MB7A	sand	weathered Bulimba Fm	6.8	
C_MB8A	siltstone	Bulimba Fm	-	0.0032
C_MB9A	siltstone/ silty clay	Bulimba Fm/ weathered Bulimba Fm	0.02	0.0012
C_MB10A	siltstone	Bulimba Fm	0.005	0.012

Notes: ** All in-situ permeability tests were falling head tests analysed using the Bouwer and Rice method for unconfined aquifers.*

*** All recovery data were from rising head tests, also analysed using the Bouwer and Rice method (1976).*

The results show that:

- The two test methods applied in this study (falling head test from in-situ permeability testing and rising head tests from recovery) provided similar results for each bore.
- The weathered Bulimba Formation permeability is between 0.001 m/day and 6.8 m/day. Permeability in the weathered Bulimba Formation spans several orders of magnitude, from low to high permeability. This is a common and expected occurrence due to natural variability in weathered rock materials. The lithology of weathered rock occurring at the screen zone of the monitoring bores ranges from clay to silty clay and sandy clay (Appendix A1). The higher permeability values were recorded within fine-grained materials and in the presence of macropores that enhance the hydraulic conductivity.
- The fresh Bulimba Formation permeability is between 0.001 m/day and 0.06 m/day. The data are well constrained within a range of one or two orders of magnitude.
- The fresh Bulimba Formation is less permeable and less variable in its permeability than the weathered Bulimba Formation.

A5 Groundwater quality and sampling

A5.1 Sampling methods

A Waterra Powerpack PP1 pump was used to purge the groundwater monitoring bores of stagnant water and collect the water samples. For bores that had high hydraulic conductivity, the samples were collected after purging a minimum of three bore volumes and stabilisation of field water quality parameters (pH, electrical conductivity [EC], oxidation-reduction potential [ORP], and temperature).

Bores that had low hydraulic conductivity were initially purged dry, and then sampled the following day after the water level in the bore had recovered. This allowed for representative samples to be obtained.

Field water quality parameters (pH, EC, ORP, temperature, total dissolved solids (TDS) and dissolved oxygen [DO]) were measured in-situ. Water quality parameters were monitored during purging using a ProDSS YSI water quality meter. This instrument was calibrated daily using factory supplied buffer solutions.

Samples were collected for laboratory analysis of physio-chemical parameters, major ions, alkalinity, TDS, dissolved metals, total metals and hydrocarbons in laboratory-supplied containers. Samples requiring dissolved metal analysis were filtered in-situ using a 0.45 micron filter. An additional sample of dissolved metals was filtered in-situ with a 0.1 micron filter to analyse for aluminium content. All samples were itemised on a Chain of Custody (COC) form and stored on ice during transit to the laboratory.

A5.2 Laboratory water quality sampling and data

Water quality samples were collected from November 2017 to February 2020.

The water samples were submitted for analysis to ALS Environmental Laboratories (ALS) which is accredited by the National Association of Testing Authorities (NATA). The groundwater samples were analysed for the following suite of parameters:

- physical parameters (pH, EC, TDS, total suspended solids [TSS], turbidity, and total hardness);
- major anions (CO_3^{-2}, HCO_3^-, Cl^-, and SO_4^{-2});
- major cations (Ca^{+2}, Mg^{+2}, Na^+, and K^+);
- dissolved and total silicon;
- dissolved and total metals (Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe^{2+}, Hg, Mn, Mo, Ni, Pb, U, Sr, Se, V, and Zn);
- dissolved aluminium (0.1 micron filtered);
- Total Petroleum Hydrocarbons (TPH), C6 – C36 fraction;
- Total Recoverable Hydrocarbons (TRH), C6 – C40 fraction;
- Benzene, Toluene, Ethylbenzene, meta- & para-Xylene, ortho-Xylene, Total Xylenes, sum of BTEX, and Naphthalene (BTEXN); and
- Volatile Organic Acids (VOA).

For comprehensive discussion of results for each stratigraphic unit refer to Sections: 5.2.4; 5.3.4; and 5.4.4 of the EIS Groundwater Report. Groundwater quality results are summarised in Appendix C of the EIS Groundwater Report.

A6 Groundwater level data

Groundwater level data were collated from two sources: manual level measurements (monthly frequency where possible), and automatic, high-frequency (4 hours), pressure readings from transducers (loggers). The logger data were corrected for changes in barometric pressure using a barometric pressure logger installed near the site; subsequently, the manual levels and the surveyed heights of the bore reference points were used to calibrate the logger pressure readings and convert them to groundwater level elevations. The data from these two sources were then compared in hydrograph charts, revealing a strong record of consistency.

The data are presented in groundwater level hydrographs in Appendix A 4. The hydrographs contain groundwater level data from November 2017 to October 2019 with manual groundwater level measurements; the base of bauxite elevation, the base of weathered Bulimba Formation elevation (where present); and the ground surface elevation (Appendix A 4).

A7 Initial bore census

An initial bore census was conducted on 20 November 2017. The primary purpose of the initial bore census was to locate and characterise deep groundwater investigation bores (RN37291 and RN37630) recorded as abandoned but usable.

The initial bore census involved:

- ground-truthing recorded bore locations;
- taking photographs of bore locations and headworks;
- recording coordinates of bore locations;
- measuring the groundwater level inside the bore if accessible; and
- making observations of the condition and type of bore/headworks.

The initial bore census inspection confirmed that:

- Deep groundwater investigation bore RN 37630 was located. The headworks of this bore are damaged and this bore is unusable (Figure A2).
- Deep groundwater investigation boreRN 37291was not encountered in the field despite a search radius of 200 m from the registered location.

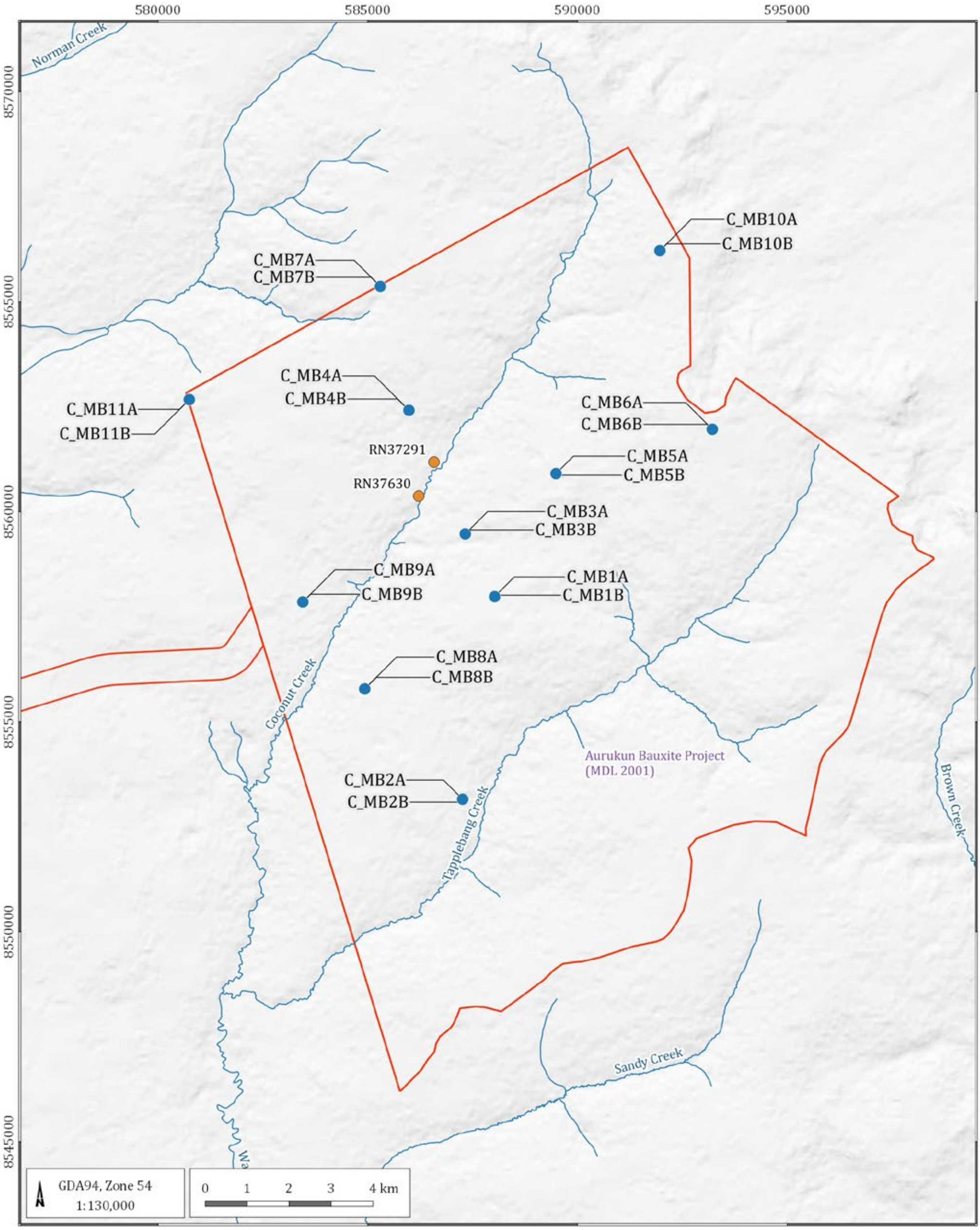
A8 References

Bouwer, H., and Rice, R.C., (1976) "A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells", *Water Resources Research,* vol. 12, no. 3, pp. 423-428.

National Uniform Drillers Licensing Committee (NUDLC), (2012), "*Minimum Construction Requirements for Water Bores in Australia*", Published by Doran Printing Pty Ltd.

Schlumberger Water Services (2011), "*Aquifer Test 2011.1*". [Program]

A9 Figures



LEGEND

- ● Aurukun Bauxite Project Groundwater monitoring bores
- ● Registered bore
- — Drainage feature
- — Project site boundary

Aurukun EIS (G1868J)

Groundwater Monitoring Bore Locations

DATE
14/08/2021

FIGURE No:
A 1

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
\\age-main01\Shared\Projects\G1868J.Aurukun_EIS\3_GIS\Workspaces\004_Deliverable4\A 01_G1868J_Groundwater Monitoring Bore Locations.qgs

Figure A2 RN 37630 – Headworks

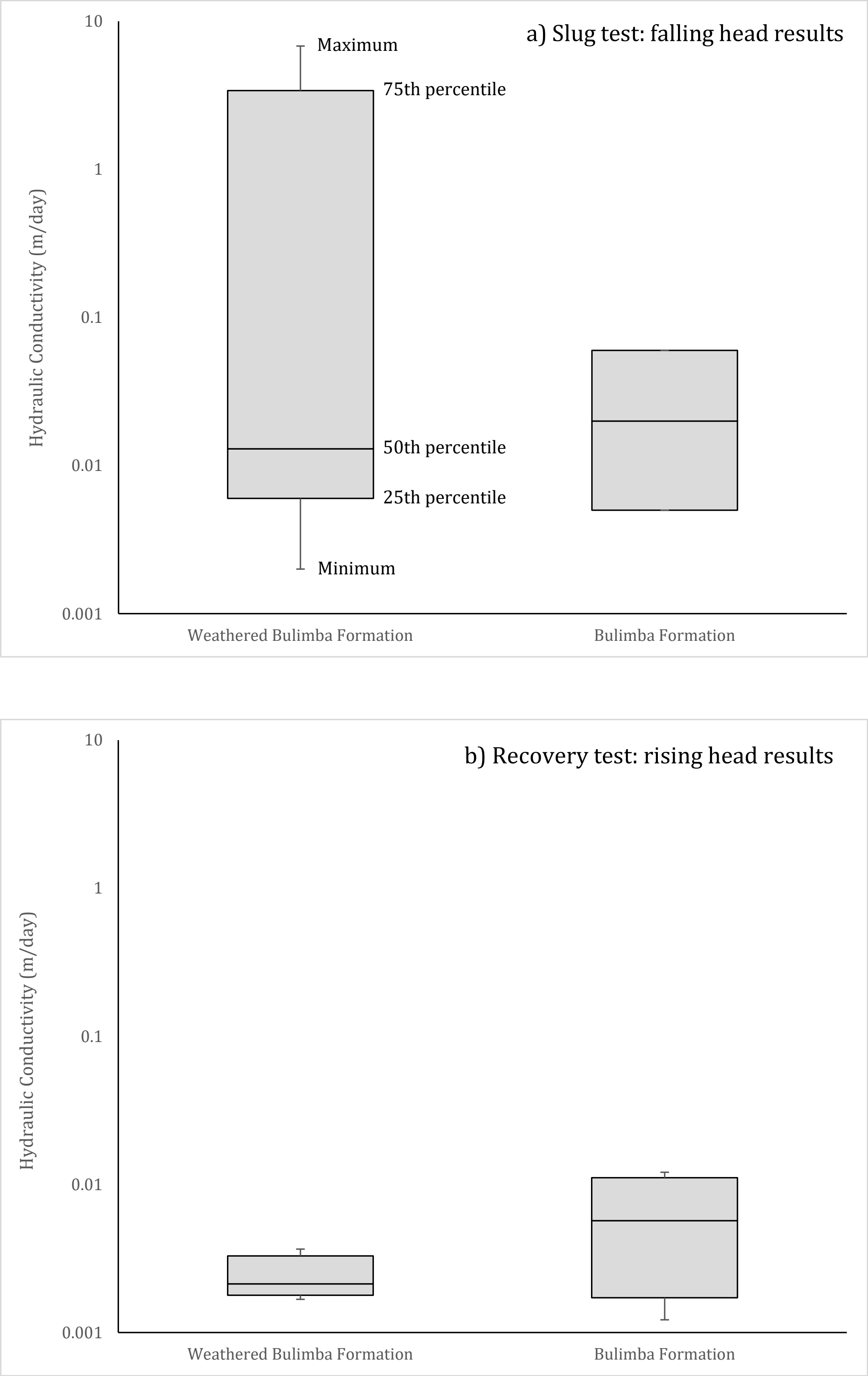


Figure A3 **Hydraulic Conductivity Dataset**

Appendix A 1 Bore construction logs

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

page:1 of 2

C_MB1A

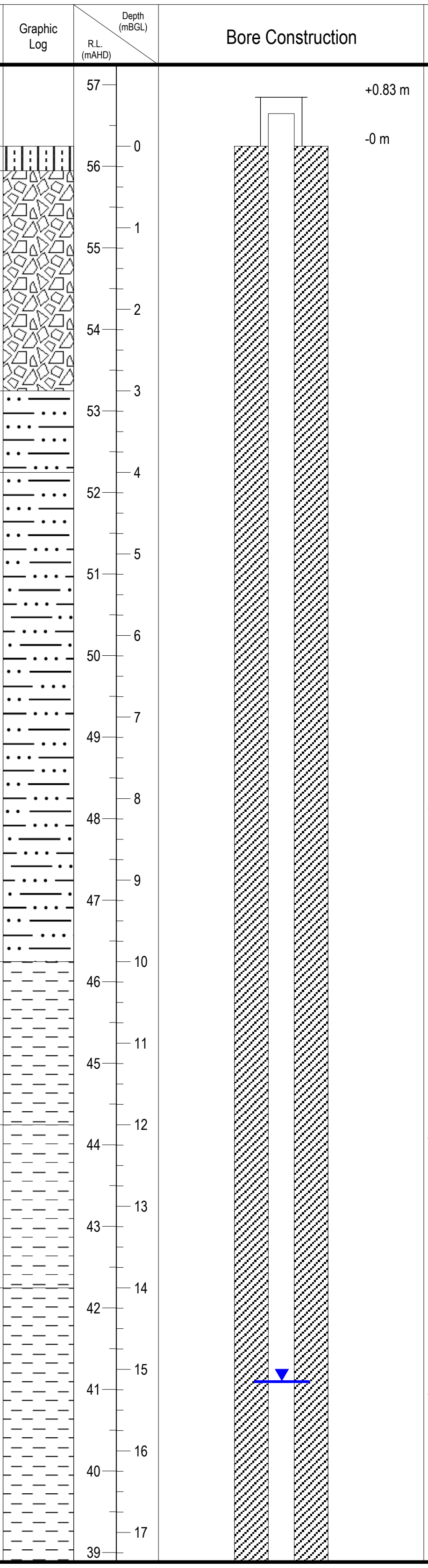
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **06/12/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **588021.217 mE**
NORTHING: **8557978.552 m**
DATUM: **GDA 94 Z 55**
RL: **56.246 mAHD**
TD: **31.7 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Soil	SOIL: Sandy, grey brown, topsoil.
Bauxite	GRAVEL: fine to medium grained, rounded, bauxite in a clay sand matrix, medium plasticity, dry to damp, red, ironstone gravel present in lower zone.
Weathered Bulimba Fm	SANDY CLAY: with ironstone, high plasticity, dry to damp, dense, reddish yellow with red brown mottling.
	SANDY CLAY: with ironstone, medium to high plasticity, dry, stiff, yellowish white with red brown and yellow mottling. Large amount of ironstone in the 10m bore returns.
	CLAY: with sand, high plasticity, dry to damp, stiff, white with some red brown mottling .
	CLAY: with ironstone, high plasticity, damp, stiff, white and red brown with an approximate 50/50 split. Brown ferruginous material.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.83 m

150 mm [Tungsten chip drill bit]: 0 m to 31.7 m (Sonic)

Grout [5 % bentonite] : 0 m to 21.5 m

50 mm uPVC blank casing: 0 m to 24.7 m

SWL: 15.15 mBGL (20/11/17)

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BOREHOLE LOG

C_MB1A

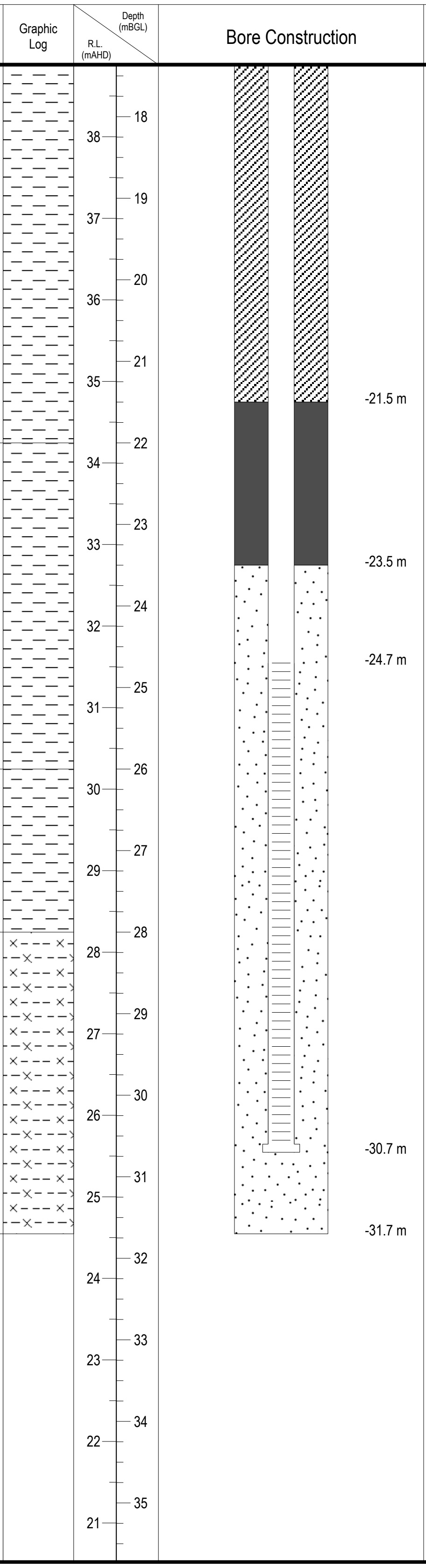
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **06/12/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **588021.217 mE**
NORTHING: **8557978.552 m**
DATUM: **GDA 94 Z 55**
RL: **56.246 mAHD**
TD: **31.7 mBGL**

COMMENTS:

Unit	Soil or Rock Field Material Description
Weathered Bulimba Fm	CLAY: with sand, high plasticity, damp to moist, soft to firm, yellow with white mottling.
	CLAY: high plasticity, moist, firm to stiff, light olive grey with yellow staining on fractures.
	CLAY: high plasticity, moist, stiff, yellow. The material has a shattered appearance when dry (high shrinkage value). The sample has a large, dry, vertical fracture down the center of the core, which has a brown infilling material. The smaller fractures
	SILTY CLAY: high plasticity, moist, firm, light grey with some yellow mottling and staining. The material has a shattered appearance when dry (high shrinkage value).



Bore Description

Bentonite seal: 21.5 m to 23.5 m

3 - 6 mm washed, rounded, quartz gravel pack: 23.5 m - 31.7 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 24.7 m to 30.7 m

End cap

End of hole: 31.7 m BGL

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BOREHOLE LOG

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C_MB1B

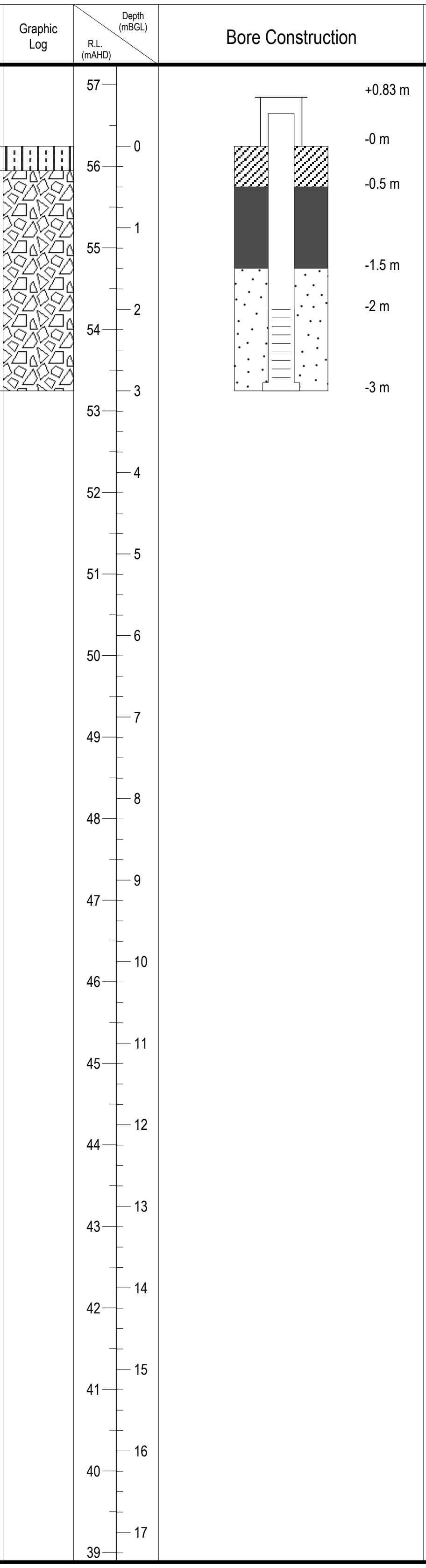
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **06/12/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **588023.331 mE**
NORTHING: **8557973.73 mN**
DATUM: **GDA 94 Z 55**
RL: **56.246 mAHD**
TD: **3 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Soil	SOIL: Sandy, grey brown, topsoil.
Bauxite	GRAVEL: fine to medium grained, rounded, bauxite in a clay sand matrix, medium plasticity, dry to damp, red, ironstone gravel present in lower zone.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.83 m

Grout [5 % bentonite] : 0.5 m to 1.5 m

Bentonite seal: 0.5 m to 1.5 m

150 mm [Tungsten chip drill bit]: 0 m to 3 m (Sonic)

Bore dry at time of construction

50 mm uPVC blank casing: 0 m to 2 m

3 - 6 mm washed, rounded, quartz gravel pack: 1.5 m - 3.0 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 2.0m to 3.0 m

End cap

End of hole: 3.0 m BGL

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BOREHOLE LOG

C_MB2A

PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **13/11/2017**
LOGGED BY: **C. Nelson (AGE)**

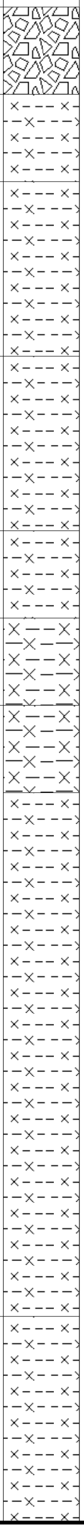
DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **587259.303 mE**
NORTHING: **8553146.443 m**
DATUM: **GDA 94 Z 55**
RL: **34.978 mAHD**
TD: **20 mBGL**

COMMENTS:

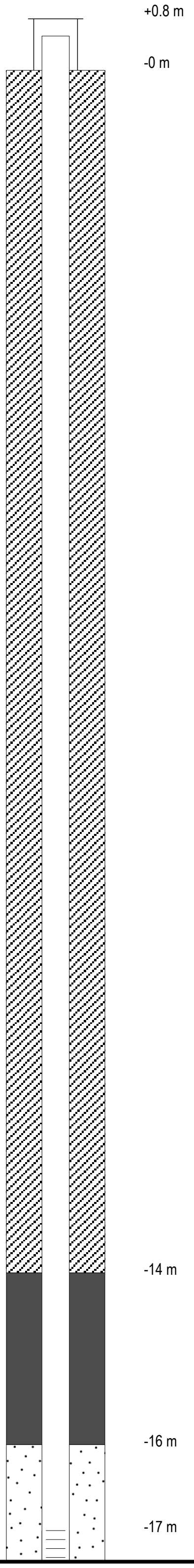
Soil or Rock Field Material Description	
Bauxite	SILTY GRAVEL: red, pisolitic.
Weathered Bulimba Fm	SILTY CLAY: red.
	SILTY CLAY: red and white with gravel.
	SILTY CLAY: red, purple mottled.
	SILTY CLAY: pink and white mottling.
	CLAYEY SILT: orange, red, mottling.
	CLAYEY SILT: orange, white, red mottling.
	SILTY CLAY: orange and white mottling.

Graphic Log



R.L. (mAHD)	Depth (mBGL)
35	0
34	1
33	2
32	3
31	4
30	5
29	6
28	7
27	8
26	9
25	10
24	11
23	12
22	13
21	14
20	15
19	16
18	17

Bore Construction



Bore Description

Protective lockable steel collar
PVC Stick up: +0.8 m

150 mm [Tungsten chip drill bit]: 0 m to 20 m (Sonic)

Grout [5 % bentonite] : 0 m to 14 m

50 mm uPVC blank casing: 0 m to 17 m

Bentonite seal: 14 m to 16 m

3 - 6 mm washed, rounded, quartz gravel pack: 16 m - 20 m

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BOREHOLE LOG

page:2 of 2

C_MB2A

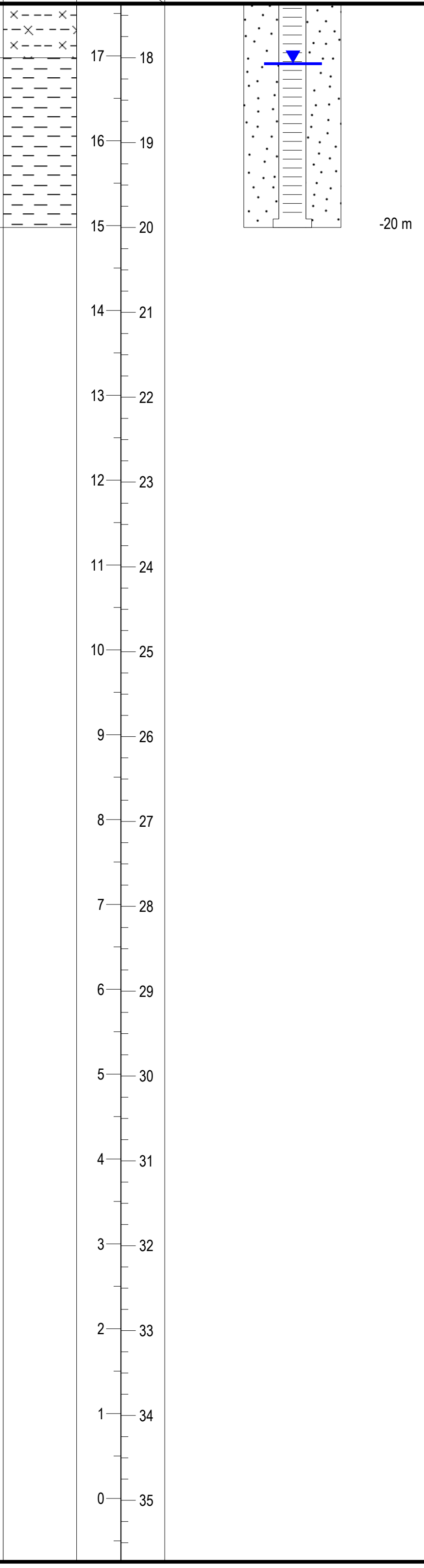
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **13/11/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **587259.303 mE**
NORTHING: **8553146.443 m**
DATUM: **GDA 94 Z 55**
RL: **34.978 mAHD**
TD: **20 mBGL**

COMMENTS:

Soil or Rock Field Material Description		Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
					50 mm uPVC machine slotted casing, slot aperture: 1 mm, 17 m to 20 m SWL: 18.07 mBGL (20/11/17)
Bulimba Fm	SILTSTONE: orange. [BULIMBA FM]			-20 m	End cap End of hole: 20m BGL



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BOREHOLE LOG

page:1 of 1

C_MB2B

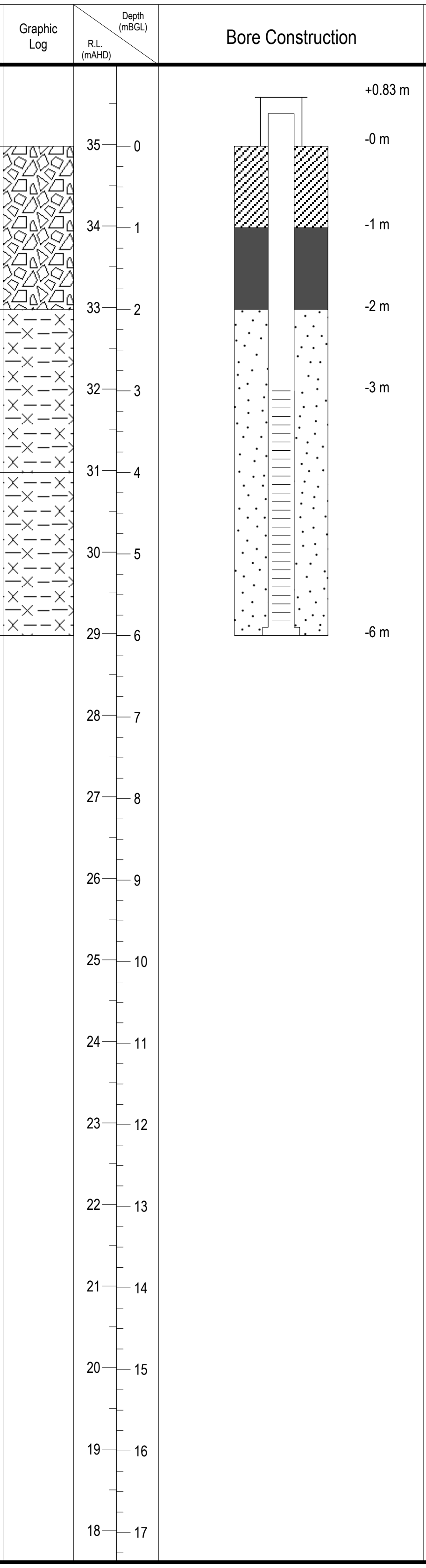
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **13/11/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **587257.002 mE**
NORTHING: **8553151.722 m**
DATUM: **GDA 94 Z 55**
RL: **34.978 mAHD**
TD: **6 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Bauxite	SILTY GRAVEL: red, pisolitic.
Weathered Bulimba Fm	CLAYEY SILT: pink with gravel.
	CLAYEY SILT: red, purple, mottled, ferruginous.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.83 m

Grout [5 % bentonite] : 0 m to 1 m

150 mm [Tungsten chip drill bit]: 0 m to 6 m (Sonic)

Bentonite seal: 1 m to 2 m

50 mm uPVC blank casing: 0 m to 3 m

3 - 6 mm washed, rounded, quartz gravel pack: 2 m - 6 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 3 m to 6 m

Bore dry at time of construction

End cap

End of hole: 6 m BGL

BOREHOLE LOG

C_MB3A

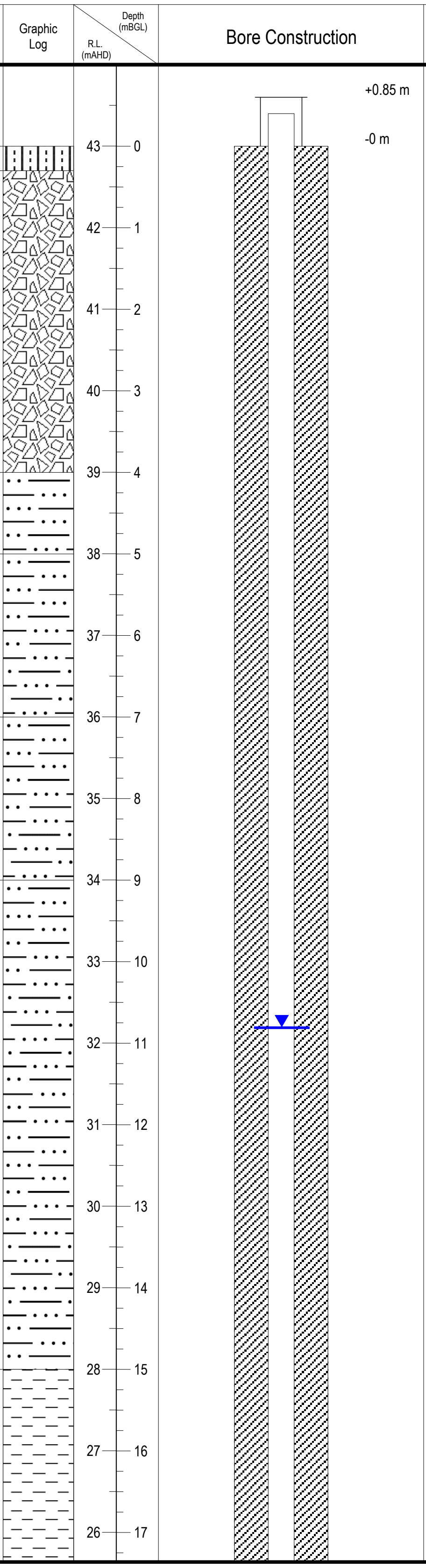
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **10/11/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **587322.873 mE**
NORTHING: **8559469.891 m**
DATUM: **GDA 94 Z 55**
RL: **42.998 mAHD**
TD: **24 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Soil	SOIL: Sandy, grey brown, topsoil.
Bauxite	GRAVEL: fine to medium grained, rounded, bauxite in a clay sand matrix, medium plasticity, dry to damp, red.
Weathered Bulimba Fm	CLAY SAND: with ironstone, high plasticity, dry to damp, dense, reddish yellow with red brown mottling.
	SANDY CLAY: with ironstone, medium to high plasticity, dry, stiff, red brown with light yellow mottling.
	SANDY CLAY: with ironstone, medium plasticity, dry, very stiff, yellow with red and white mottling.
	SANDY CLAY: with ironstone, medium plasticity, dry to damp, very stiff, yellow with red brown and white mottling. Medium to coarse gravel is present in the sample.
	CLAY: high plasticity, moist, stiff, yellow with white and red brown mottling.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.85 m

150 mm [Tungsten chip drill bit]: 0 m to 24 m (Sonic)

Grout [5 % bentonite] : 0 m to 18 m

50 mm uPVC blank casing: 0 m to 21 m

SWL: 10.81 mBGL (20/11/17)

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BOREHOLE LOG

C_MB3A

PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **10/11/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **587322.873 mE**
NORTHING: **8559469.891 m**
DATUM: **GDA 94 Z 55**
RL: **42.998 mAHD**
TD: **24 mBGL**

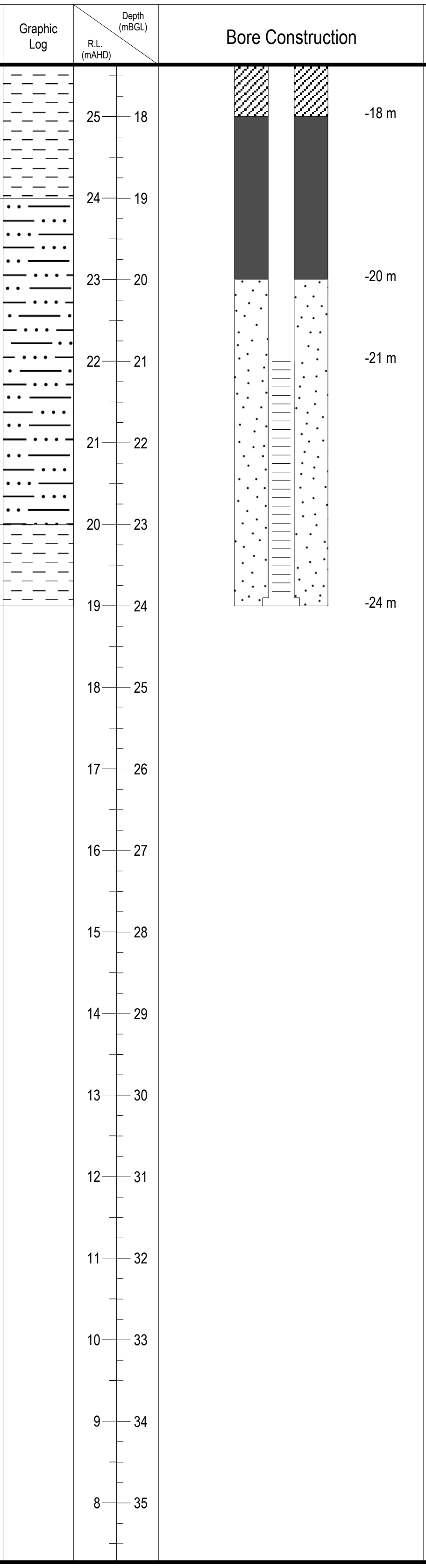
COMMENTS:

Soil or Rock Field Material Description

Weathered Bulimba Fm

SANDY CLAY: medium to high plasticity, moist, stiff, yellow with light grey and brown mottling.

CLAY: high plasticity, moist, very stiff, light grey, with yellow staining on fracture surfaces.



Bore Description

Bentonite seal: 18 m to 20 m

3 - 6 mm washed, rounded, quartz gravel pack: 20 m - 24 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 21 m to 24 m

End cap
End of hole: 24 m BGL

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BOREHOLE LOG

page:1 of 1

C_MB3B

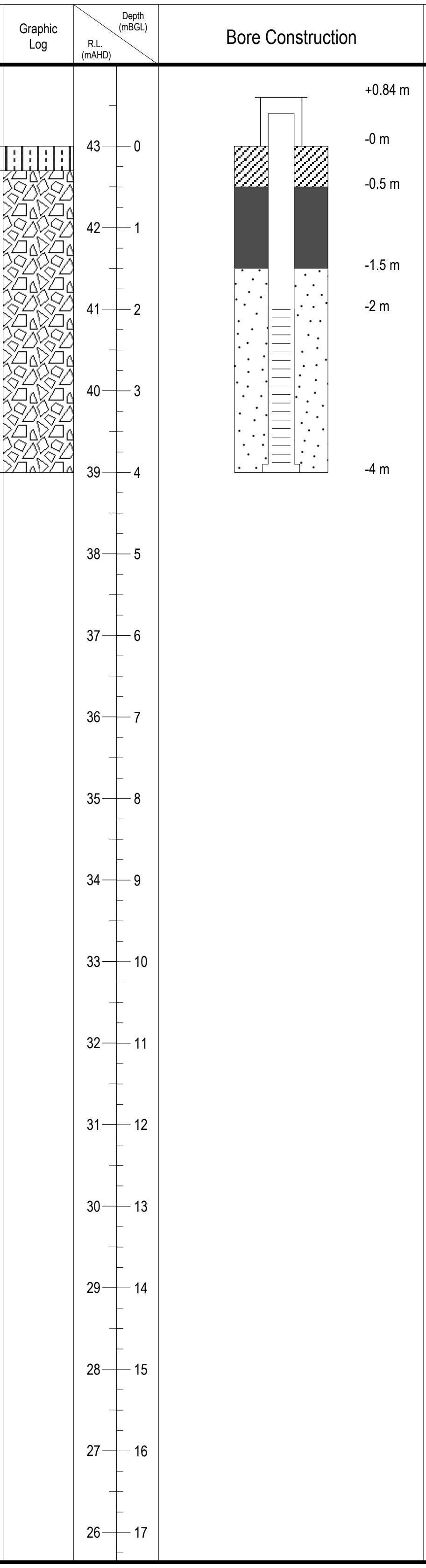
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **06/12/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **587321.359 mE**
NORTHING: **8559473.892 m**
DATUM: **GDA 94 Z 55**
RL: **42.998 mAHD**
TD: **4 mBGL**

COMMENTS:

Soil or Rock Field Material Description	
Soil	SOIL: Sandy, grey brown, topsoil.
Bauxite	GRAVEL: Gravel, fine to medium grained, rounded, bauxite in a clay sand matrix, medium plasticity, dry to damp, red.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.84 m

Grout [5 % bentonite] : 0 m to 0.5 m

Bentonite seal: 0.5 m to 1.5 m

150 mm [Tungsten chip drill bit]: 0 m to 4 m (Sonic)

Bore dry at time of construction

50 mm uPVC blank casing: 0 m to 2 m

3 - 6 mm washed, rounded, quartz gravel pack: 1.5 m - 4 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 2 m to 4 m

End cap

End of hole: 4 m BGL

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

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C_MB4A

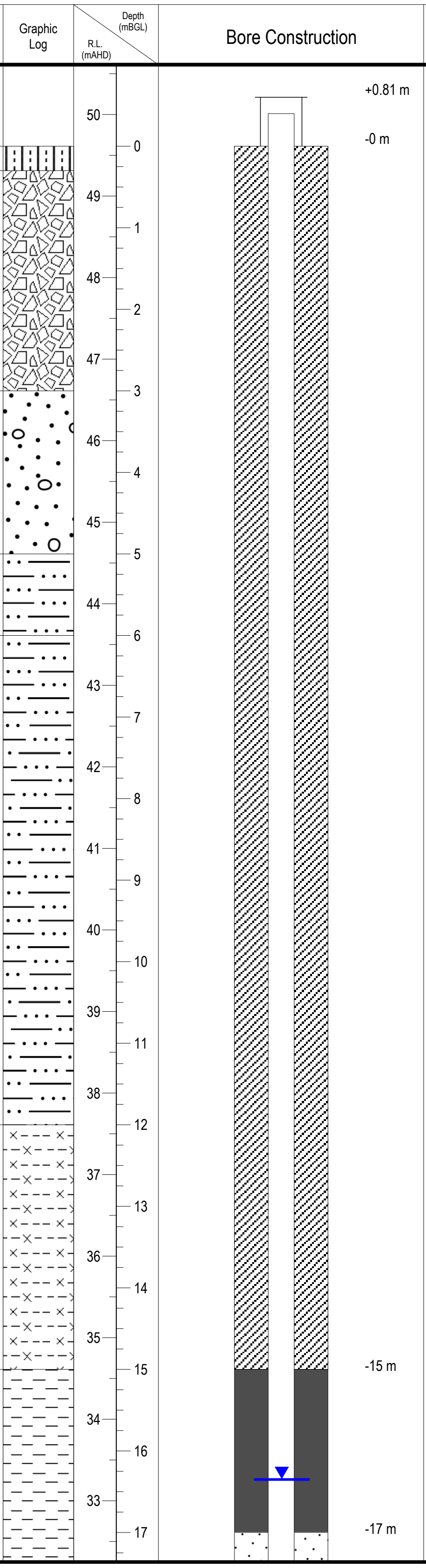
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **11/10/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **585977.987 mE**
NORTHING: **8562414.192 m**
DATUM: **GDA 94 Z 55**
RL: **49.611 mAHD**
TD: **21 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Soil	SOIL: Sandy, grey brown, topsoil.
Bauxite	GRAVEL: fine to medium grained, rounded, bauxite in a clay sand matrix, medium plasticity, damp to moist, red.
Weathered Bulimba Fm	SANDY GRAVEL: Sand clay gravel, fine to medium grained, rounded, medium to high plasticity, moist, red
	CLAY SAND: with ironstone, high plasticity, dry to damp, dense, reddish yellow with red brown mottling.
	SANDY CLAY: with ironstone, yellow with white and red brown mottling.
	SILTY CLAY: with ironstone, high plasticity, dry to damp, very stiff, white with red and yellow mottling.
	CLAY: high plasticity, moist, very stiff, yellow with white mottling.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.81 m

150 mm [Tungsten chip drill bit]: 0 m to 21 m (Sonic)

Grout [5 % bentonite] : 0 m to 15 m

50 mm uPVC blank casing: 0 m to 18 m

Bentonite seal: 15 m to 17 m

SWL: 16.35 mBGL (18/11/17)

C_MB4A

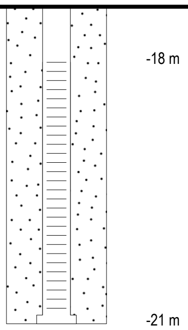
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **11/10/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **585977.987 mE**
NORTHING: **8562414.192 m**
DATUM: **GDA 94 Z 55**
RL: **49.611 mAHD**
TD: **21 mBGL**

COMMENTS:

	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
Weathered Bulimba Fm					
	CLAY: high plasticity, moist, very stiff, yellowish white with light red mottling.				3 - 6 mm washed, rounded, quartz gravel pack: 17 m - 21 m 50 mm uPVC machine slotted casing, slot aperture: 1 mm, 18 m to 21 m
	CLAY: high plasticity, moist, very stiff, yellow with white mottling.				End cap End of hole: 21 m BGL



R.L. (mAHD)	Depth (mBGL)
32	18
31	19
30	20
29	21
28	22
27	23
26	24
25	25
24	26
23	27
22	28
21	29
20	30
19	31
18	32
17	33
16	34
15	35
14	

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BOREHOLE LOG

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C_MB4B

PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **06/12/2017**
LOGGED BY: **C. Nelson (AGE)**

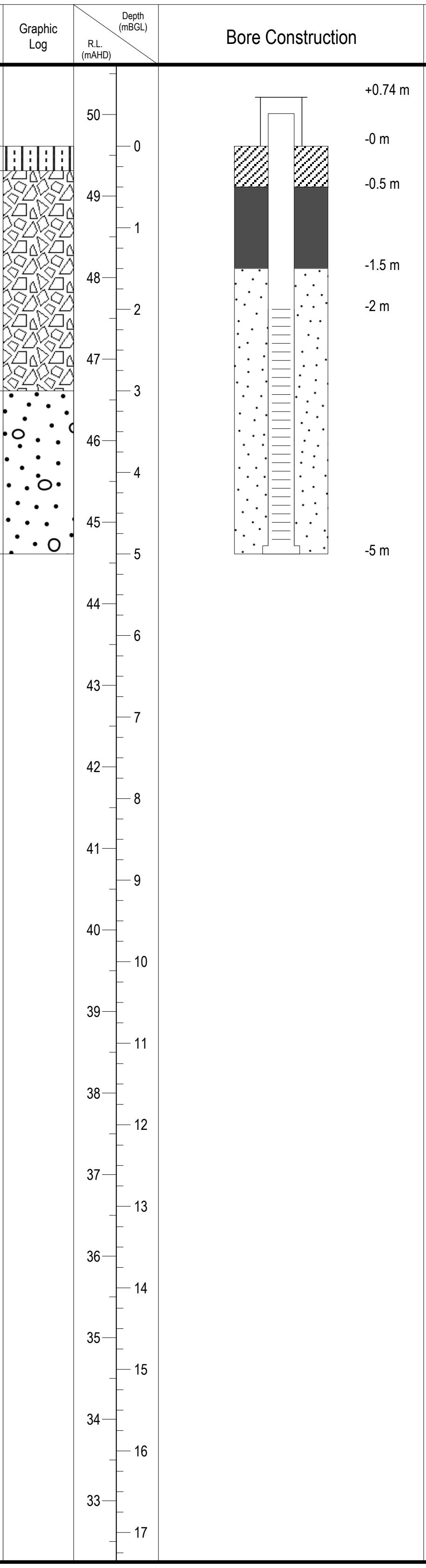
DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **585976.198 mE**
NORTHING: **8562418.908 m**
DATUM: **GDA 94 Z 55**
RL: **49.611 mAHD**
TD: **5 mBGL**

COMMENTS:

Soil or Rock Field Material Description

Soil	SOIL: Sandy, grey brown, topsoil.
Bauxite	GRAVEL:, fine to medium grained, rounded, bauxite in a clay sand matrix, medium plasticity, damp to moist, red
Weathered Bulimba Fm	SANDY GRAVEL: Sand clay gravel, fine to medium grained, rounded, medium to high plasticity, moist, red



Bore Description

Protective lockable steel collar
PVC Stick up: +0.74 m

Grout [5 % bentonite] : 0 m to 0.5 m

Bentonite seal: 0.5 m to 1.5 m

150 mm [Tungsten chip drill bit]: 0 m to 5 m (Sonic)

50 mm uPVC blank casing: 0 m to 2 m

Bore dry at time of construction

3 - 6 mm washed, rounded, quartz gravel pack: 1.5 m - 5 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 2 m to 5 m

End cap
End of hole: 5 m BGL

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BOREHOLE LOG

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C_MB5A

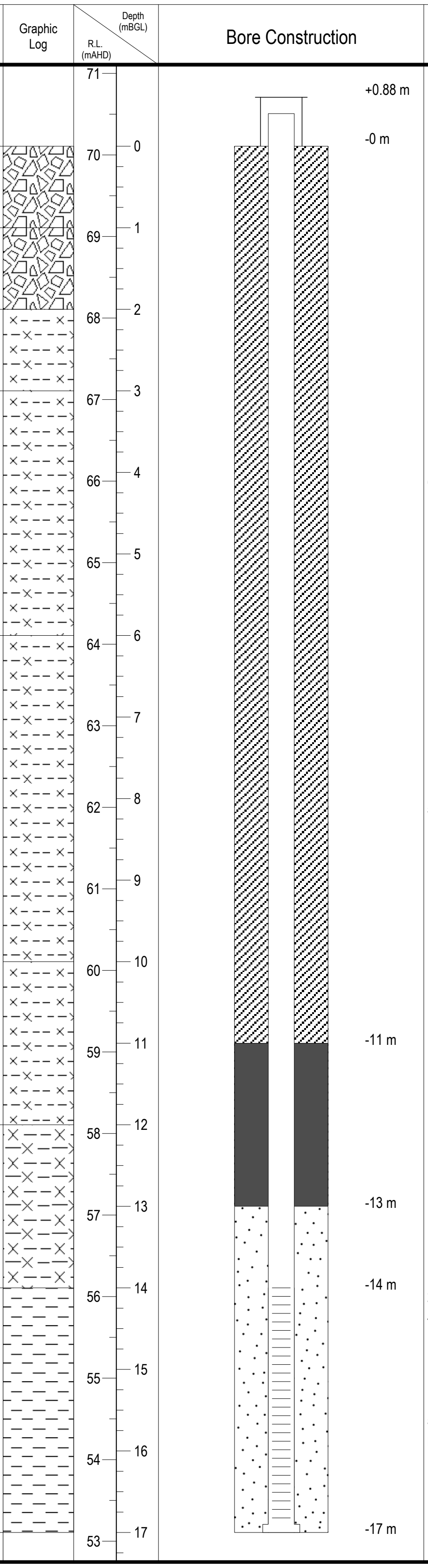
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **13/11/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **589476.654 mE**
NORTHING: **8560908.647 m**
DATUM: **GDA 94 Z 55**
RL: **70.107 mAHD**
TD: **17 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Bauxite	CLAYEY SILT: red.
	SILTY CLAY: red and white.
Weathered Bulimba Fm	SILTY CLAY: orange, red and white mottled.
	SILTY CLAY: orange, white, purple.
	SILTY CLAY: orange and white.
	CLAYEY SILTSTONE: BULIMBA FM.
Bulimba Fm	[BULIMBA FM].



Bore Description

Protective lockable steel collar
PVC Stick up: +0.88 m

150 mm [Tungsten chip drill bit]: 0 m to 17 m (Sonic)

Grout [5 % bentonite] : 0 m to 13 m

50 mm uPVC blank casing: 0 m to 14 m

Bentonite seal: 11 m to 13 m

3 - 6 mm washed, rounded, quartz gravel pack: 13 m - 17 m

Bore dry at time of construction

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 14 m to 17 m

End cap

End of hole: 17 m BGL

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

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C_MB5B

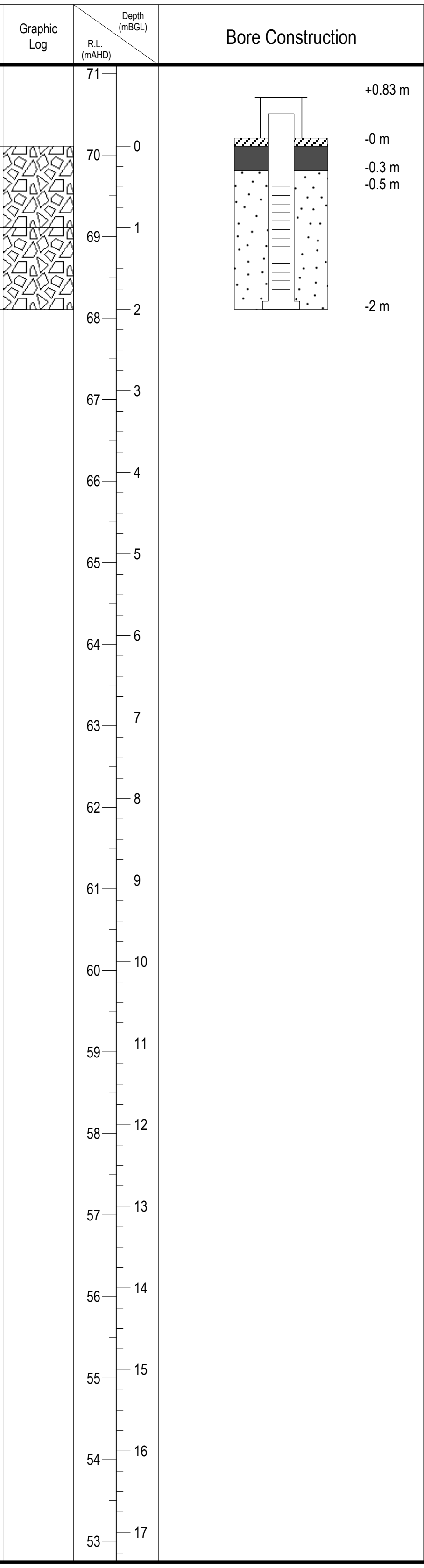
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **13/11/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **589481.794 mE**
NORTHING: **8560909.559 m**
DATUM: **GDA 94 Z 55**
RL: **70.107 mAHD**
TD: **2 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Bauxite	CLAYEY SILT: red.
	SILTY CLAY: red and white.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.83 m

Grout [5 % bentonite] : Surface

Bentonite seal: 0 m to 0.3 m

Bore dry at time of construction

150 mm [Tungsten chip drill bit]: 0 m to 2 m (Sonic)

50 mm uPVC blank casing: 0 m to 0.5 m

3 - 6 mm washed, rounded, quartz gravel pack: 0.3 m - 2 m
50 mm uPVC machine slotted casing, slot aperture: 1 mm, 0.5 m to 2 m

End cap

End of hole: 2 m BGL

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

C_MB6A

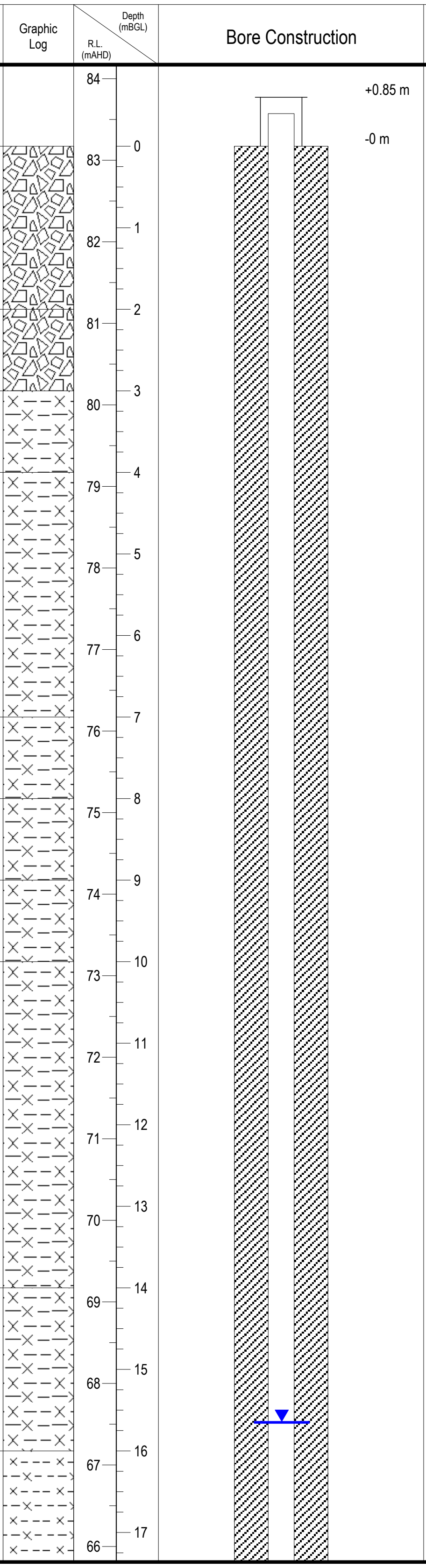
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **14/11/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **593215.394 mE**
NORTHING: **8561963.524 m**
DATUM: **GDA 94 Z 55**
RL: **83.172 mAHD**
TD: **23.5 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Bauxite	CLAYEY SILT: red piesolitic.
	CLAYEY SILT: red and white piesolitic.
Weathered Bulimba Fm	CLAYEY SILT: red, white, purple.
	CLAYEY SILT: red, white, yellow, purple, mottled, ferruginous.
	CLAYEY SILT: pink and white.
	CLAYEY SILT: purple, red, white, ferruginous.
	CLAYEY SILT: white, orange, red, mottled.
	CLAYEY SILT: white, purple, yellow, mottled.
	CLAYEY SILT: orange and purple.
	SILTY CLAY: orange and white, mottled.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.85 m

150 mm [Tungsten chip drill bit]: 0 m to 23.5 m (Sonic)

Grout [5 % bentonite] : 0 m to 17.5 m

50 mm uPVC blank casing: 0 m to 20.5 m

SWL: 15.65 mTOC (18/11/17)

C_MB6A

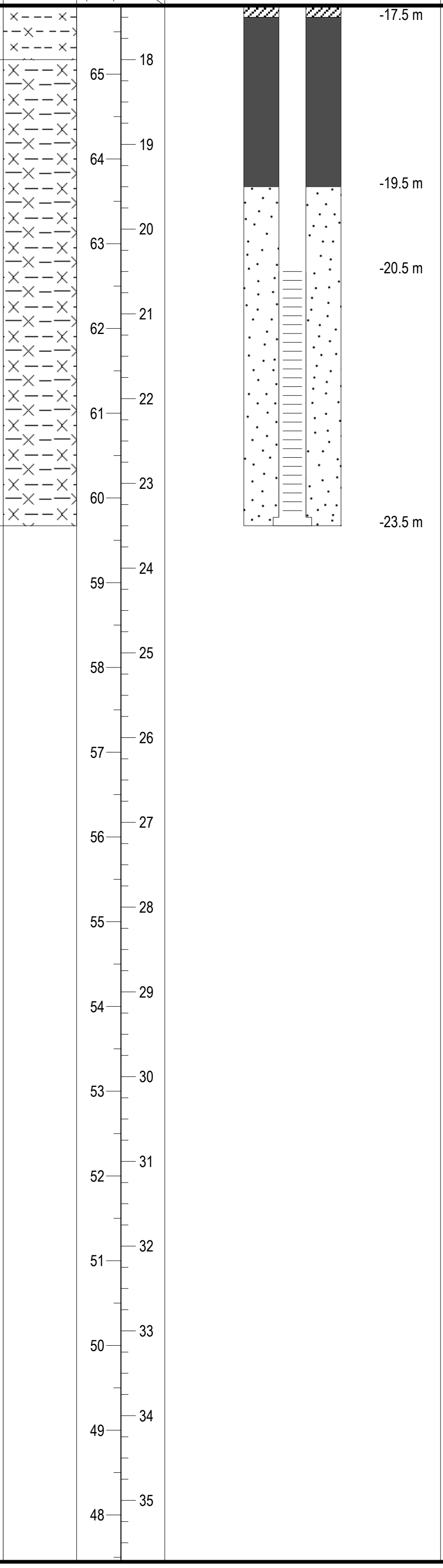
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **14/11/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **593215.394 mE**
NORTHING: **8561963.524 m**
DATUM: **GDA 94 Z 55**
RL: **83.172 mAHD**
TD: **23.5 mBGL**

COMMENTS:

Soil or Rock Field Material Description	
🟩	
Bulimba Fm	SILTSTONE: clayey silt, orange. [BULIMBA FM]



Bore Description

Bentonite seal: 17.5 m to 19.5 m

3 - 6 mm washed, rounded, quartz gravel pack: 19.5 m - 23.5 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 20.5 m to 23.5 m

End cap

End of hole: 23.5 m BGL

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BOREHOLE LOG

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C_MB6B

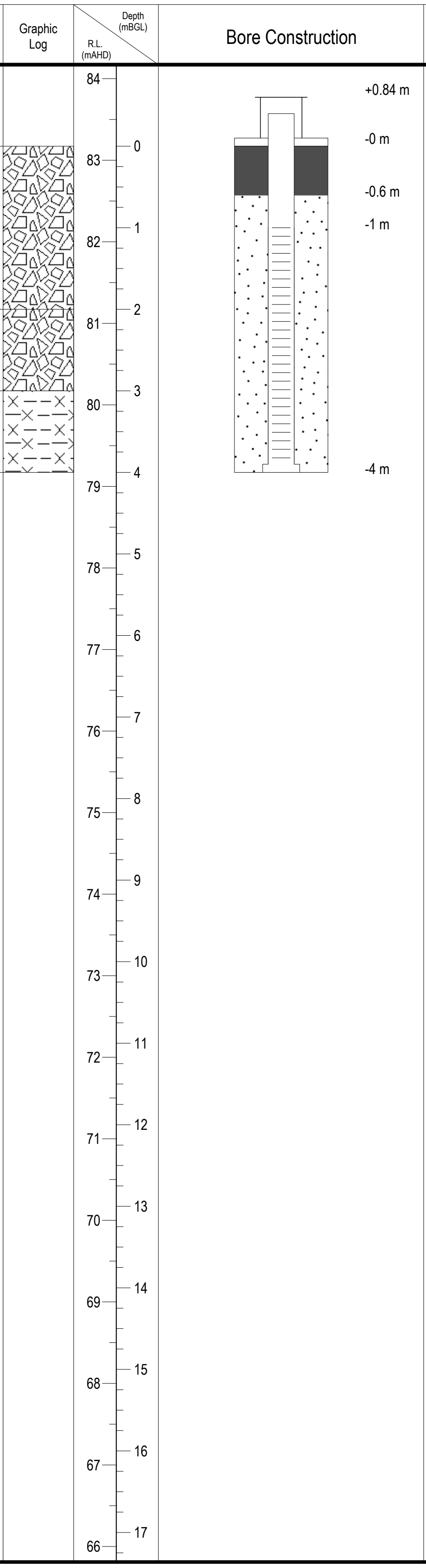
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **14/11/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **593211.025 mE**
NORTHING: **8561962.642 m**
DATUM: **GDA 94 Z 55**
RL: **83.172 mAHD**
TD: **4 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Bauxite	CLAYEY SILT: red, pisolitic.
	CLAYEY SILT: red and white pisolitic.
Weathered Bulimba Fm	CLAYEY SILT: red, white, purple.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.84 m

Grout [5 % bentonite] : Surface

Bentonite seal: 0 m to 0.6 m

150 mm [Tungsten chip drill bit]: 0 m to 4 m (Sonic)

50 mm uPVC blank casing: 0 m to 1 m

Bore dry at time of construction

3 - 6 mm washed, rounded, quartz gravel pack: 0.6 m - 4 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 1 m to 4 m

End cap

End of hole: 4 m BGL

BOREHOLE LOG

C_MB7A

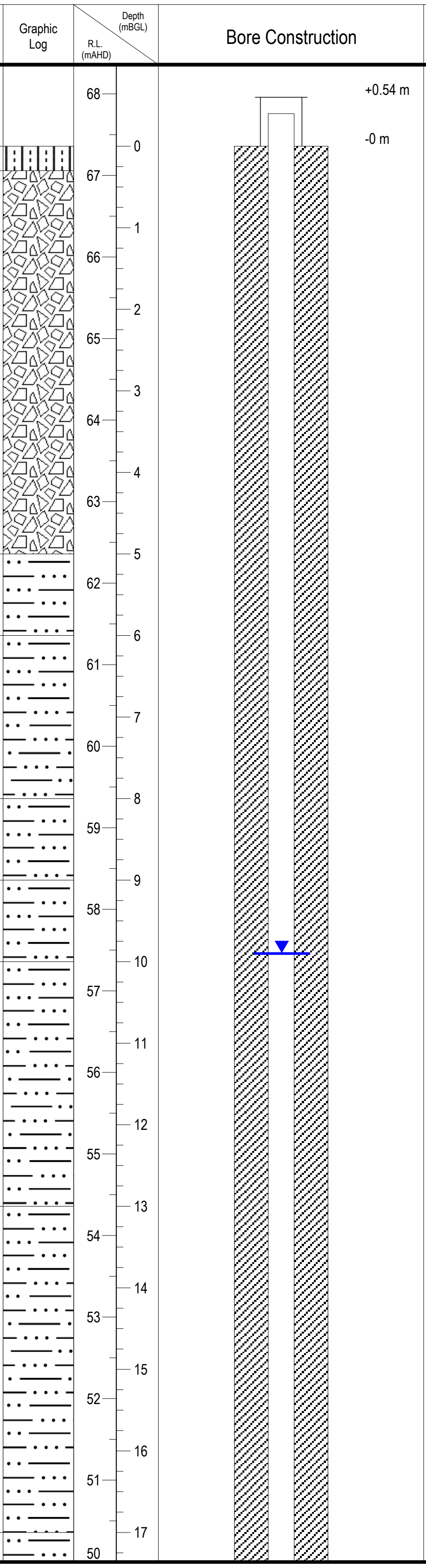
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **08/11/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **585301.685 mE**
NORTHING: **8565366.053 m**
DATUM: **GDA 94 Z 55**
RL: **67.358 mAHD**
TD: **32 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Soil	SOIL: Sandy, grey brown, topsoil.
Bauxite	GRAVEL: fine to medium grained, rounded, bauxite in a clay sand matrix, medium plasticity, damp, red, ironstone gravel present in lower zone.
Weathered Bulimba Fm	CLAYEY SAND: with ironstone, fine grained, low to medium plasticity, dry to damp, dense, reddish yellow with red brown mottling.
	SANDY CLAY: medium plasticity, dry, very stiff, light yellow with white and brown mottling.
	CLAYEY SAND: fine grained, low plasticity, dry, dense, greyish white with red brown mottling.
	SAND: traces of clay, fine to medium grained, well graded, quartz, angular, low plasticity, moist, loose to medium dense, greyish white with yellow mottling.
	SAND: traces of clay, fine to medium grained, well graded, quartz, angular, low plasticity, wet, loose, greyish white with yellow mottling.
	CLAYEY SAND: fine grained, medium plasticity, wet, soft, light grey.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.54 m

150 mm [Tungsten chip drill bit]: 0 m to 32 m (Sonic)

Grout [5 % bentonite] : 0 m to 21.5 m

SWL: 9.9 mBGL (18/11/17)

50 mm uPVC blank casing: 0 m to 24.5 m

BOREHOLE LOG

C_MB7A

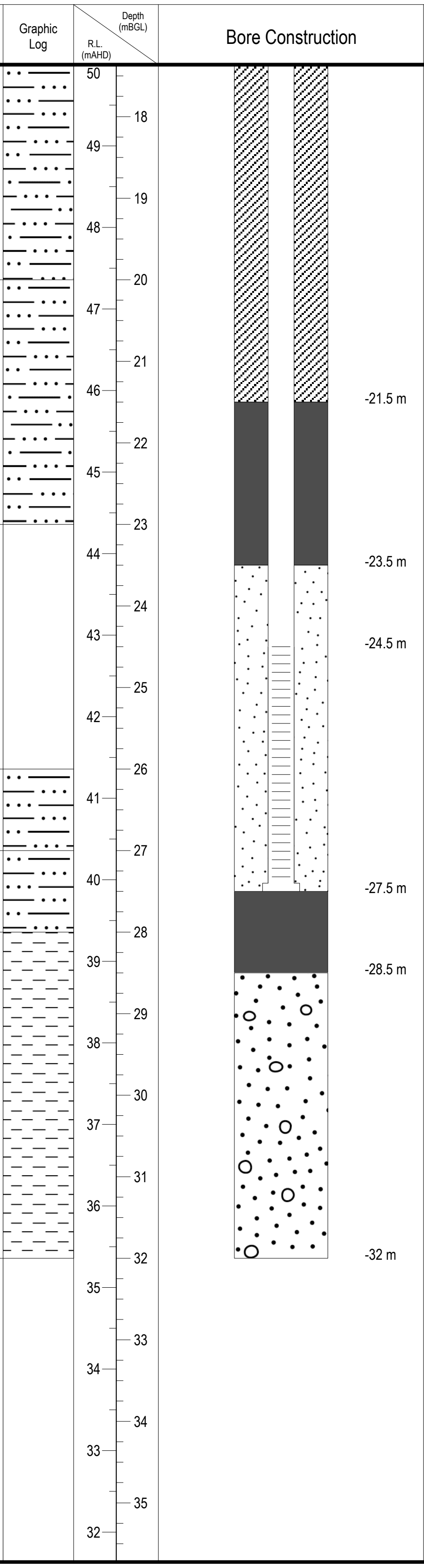
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **08/11/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **585301.685 mE**
NORTHING: **8565366.053 m**
DATUM: **GDA 94 Z 55**
RL: **67.358 mAHD**
TD: **32 mBGL**

COMMENTS:

Soil or Rock Field Material Description	
Weathered Bulimba Fm	SAND: traces of clay, fine to medium grained, well graded, quartz, angular, wet, loose, light grey with large amount of brown and yellow mottling.
	SAND: traces of clay, fine to medium grained, well graded, quartz, angular, wet, loose, light grey with some of brown and yellow mottling.
	MATERIAL LOSS
	SAND: traces of clay, fine to medium grained, well graded, quartz, angular, wet, loose, light grey with some of brown and yellow mottling.
	SAND: traces of clay, fine to medium grained, well graded, quartz, angular, moist, dense, light grey with some of brown mottling.
	CLAY: high plasticity, moist, very stiff, yellow with white mottling.



Bore Description

Bentonite seal: 21.5 m to 23.5 m

3 - 6 mm washed, rounded, quartz gravel pack: 23.5 m - 27.5 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 24.5 m to 27.5 m

End cap
End of hole: 27.5 m BGL

Bentonite seal: 27.5 m to 28.5 m

Backfill: 28.5 m to 32.0 m

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BOREHOLE LOG

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C_MB7B

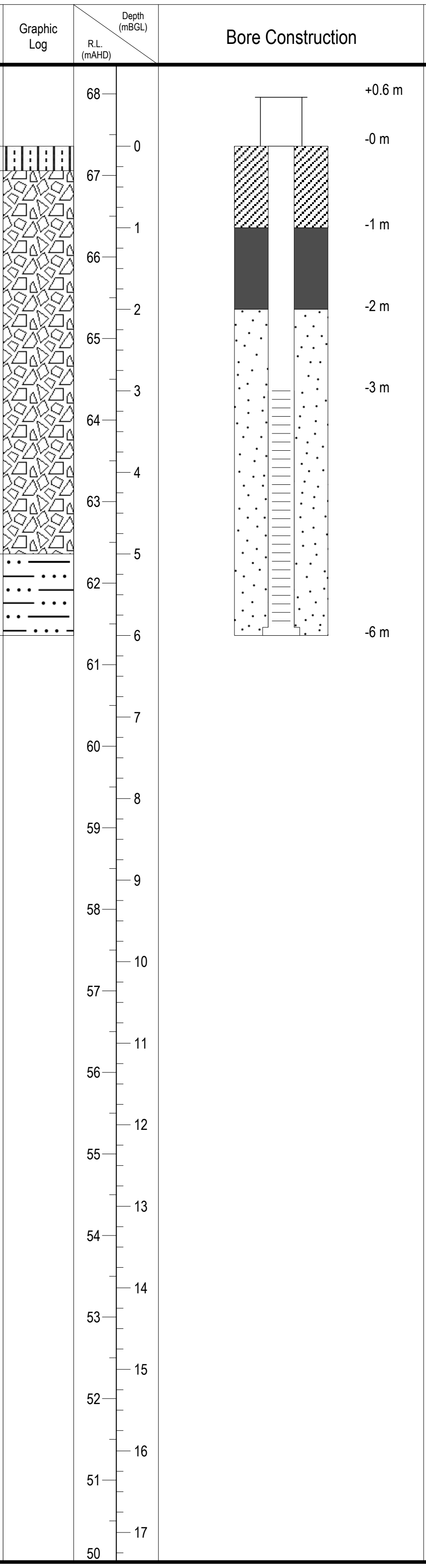
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **06/12/2017**
LOGGED BY: **C. Nelson (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **585304.31 mE**
NORTHING: **8565369.913 m**
DATUM: **GDA 94 Z 55**
RL: **67.358 mAHD**
TD: **6 mBGL**

COMMENTS:

Soil or Rock Field Material Description	
Soil	SOIL: Sandy, grey brown, topsoil.
Bauxite	GRAVEL: fine to medium grained, rounded, bauxite in a clay sand matrix, medium plasticity, damp, red, ironstone gravel present in lower zone.
Weathered Bulimba Fm	CLAYEY SAND: with ironstone, fine grained, low to medium plasticity, dry to damp, dense, reddish yellow with red brown mottling.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.6 m

Grout [5 % bentonite] : 0 m to 1 m

150 mm [Tungsten chip drill bit]: 0 m to 6 m (Sonic)

Bentonite seal: 1 m to 2 m

50 mm uPVC blank casing: 0 m to 3 m

3 - 6 mm washed, rounded, quartz gravel pack: 2 m - 6 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 3 m to 6 m

Bore dry at time of construction

End cap

End of hole: 6 m BGL

Australasian Groundwater & Environmental Consultants Pty Ltd

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BOREHOLE LOG

C_MB8A

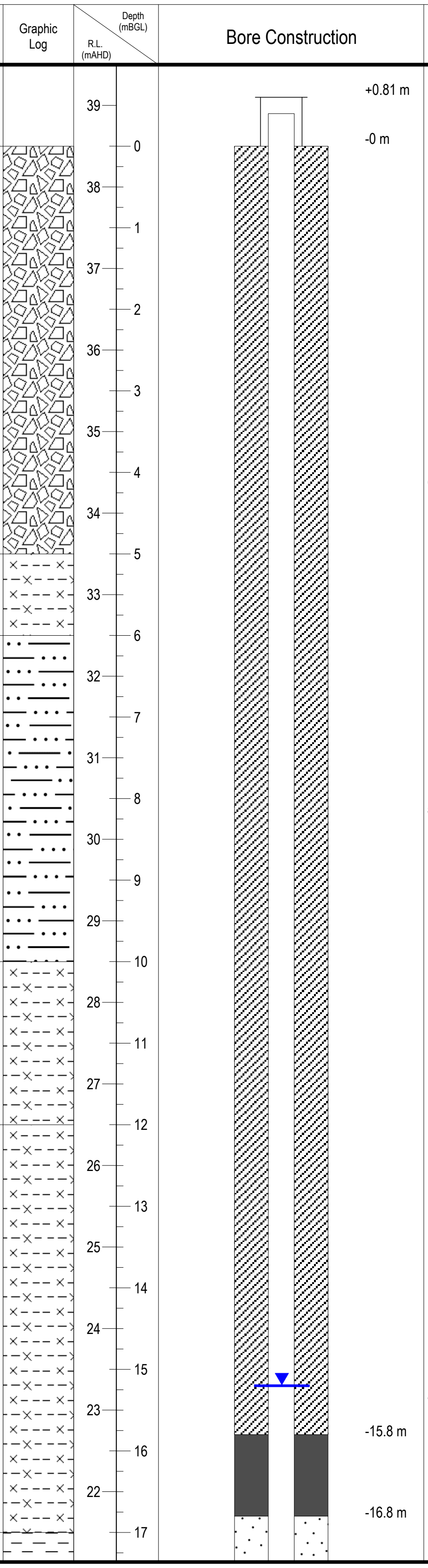
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **12/11/2017**
LOGGED BY: **L. Furness (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **584923.334 mE**
NORTHING: **8555777.134 m**
DATUM: **GDA 94 Z 55**
RL: **38.499 mAHD**
TD: **20.8 mBGL**

COMMENTS:

Soil or Rock Field Material Description	
Bauxite	CLAYEY SILT: red.
Weathered Bulimba Fm	SILTY CLAY: pink, yellow, white mottled.
	CLAYEY SAND: pink and white.
	SILTY CLAY: red, orange, white.
	SILTY CLAY: orange and white.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.81 m

150 mm [Tungsten chip drill bit]: 0 m to 20.8 m (Sonic)

Grout [5 % bentonite] : 0 m to 15.8 m

50 mm uPVC blank casing: 0 m to 17.8 m

SWL: 15.2 mTOC (20/11/17)

Bentonite seal: 15.8 m to 16.8 m

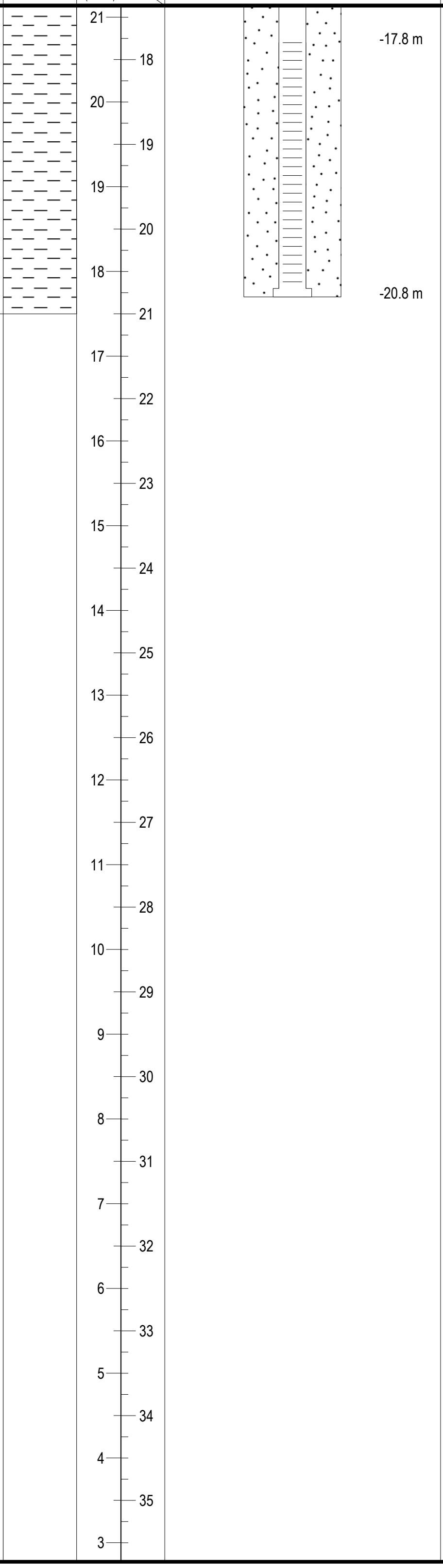
3 - 6 mm washed, rounded, quartz gravel pack: 16.8

PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **12/11/2017**
LOGGED BY: **L. Furness (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **584923.334 mE**
NORTHING: **8555777.134 m**
DATUM: **GDA 94 Z 55**
RL: **38.499 mAHD**
TD: **20.8 mBGL**

COMMENTS:

Soil or Rock Field Material Description		Graphic Log / R.L. (mAHD) / Depth (mBGL) / Bore Construction	Bore Description
Bulimba Fm	SILTSTONE: light grey with white flecks. [BULIMBA FM]		m - 20.8 m 50 mm uPVC machine slotted casing, slot aperture: 1 mm, 17.8 m to 20.8 m End cap End of hole: 20.8 m BGL

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

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C_MB8B

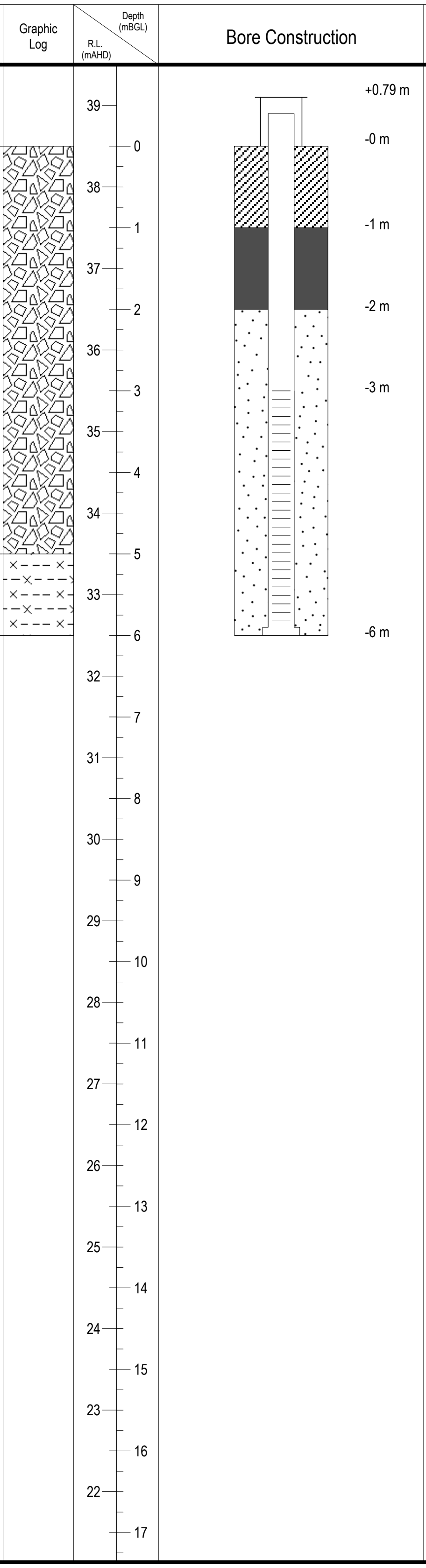
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **12/11/2017**
LOGGED BY: **L. Furness (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **584926.044 mE**
NORTHING: **8555780.992 m**
DATUM: **GDA 94 Z 55**
RL: **38.499 mAHD**
TD: **6 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Bauxite	CLAYEY SILT: red.
Weathered Bulimba Fm	SILTY CLAY: pink, yellow, white mottled.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.79 m

Grout [5 % bentonite] : 0 m to 1 m

150 mm [Tungsten chip drill bit]: 0 m to 6 m (Sonic)

Bentonite seal: 1 m to 2 m

50 mm uPVC blank casing: 0 m to 3 m

3 - 6 mm washed, rounded, quartz gravel pack: 2 m - 6 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 3 m to 6 m

Bore dry at time of construction

End cap

End of hole: 6 m BGL

Australasian Groundwater & Environmental Consultants Pty Ltd
Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

C_MB9A

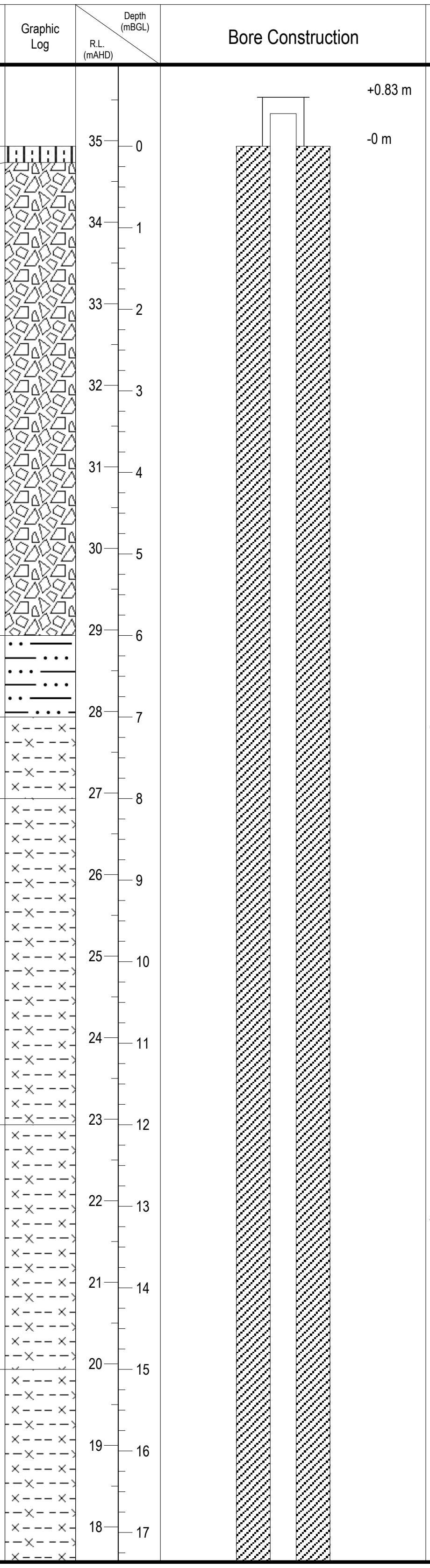
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **12/11/2017**
LOGGED BY: **L. Furness (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **583450.054 mE**
NORTHING: **8557847.696 m**
DATUM: **GDA 94 Z 55**
RL: **34.932 mAHD**
TD: **27 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Soil	SOIL: brown silty gravel, pisolitic.
Bauxite	BAUXITE: red, pisolitic.
Weathered Bulimba Fm	SANDY CLAY: red and orange.
	SILTY CLAY: orange, red, white mottled.
	SILTY CLAY: orange, white mottled.
	SILTY CLAY: orange and white mottled, some ferruginous zones.
	SILTY CLAY: orange and white.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.83 m

150 mm [Tungsten chip drill bit]: 0 m to 27 m (Sonic)

Grout [5 % bentonite] : 0 m to 20.8 m

50 mm uPVC blank casing: 0 m to 24 m

BOREHOLE LOG

C_MB9A

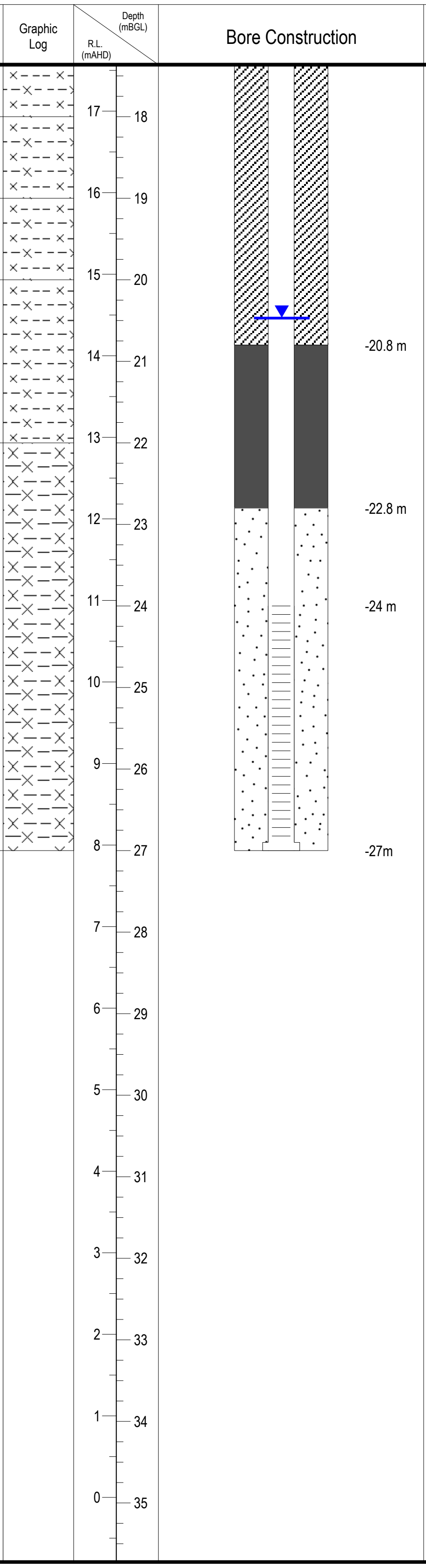
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **12/11/2017**
LOGGED BY: **L. Furness (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **583450.054 mE**
NORTHING: **8557847.696 m**
DATUM: **GDA 94 Z 55**
RL: **34.932 mAHD**
TD: **27 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Weathered Bulimba Fm	
	SILTY CLAY: pink.
	SILTY CLAY: orange.
	SILTY CLAY: orange and white veins.
Bulimba Fm	SILTSTONE: orange-brown silty clay. [BULIMBA FM]



Bore Description

SWL: 20.47 mBGL (20/11/17)

Bentonite seal: 20.8 m to 22.8 m

3 - 6 mm washed, rounded, quartz gravel pack: 22.8 m - 27 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 24 m to 27 m

End cap
End of hole: 27 m BGL

Australasian Groundwater & Environmental Consultants Pty Ltd
Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

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C_MB9B

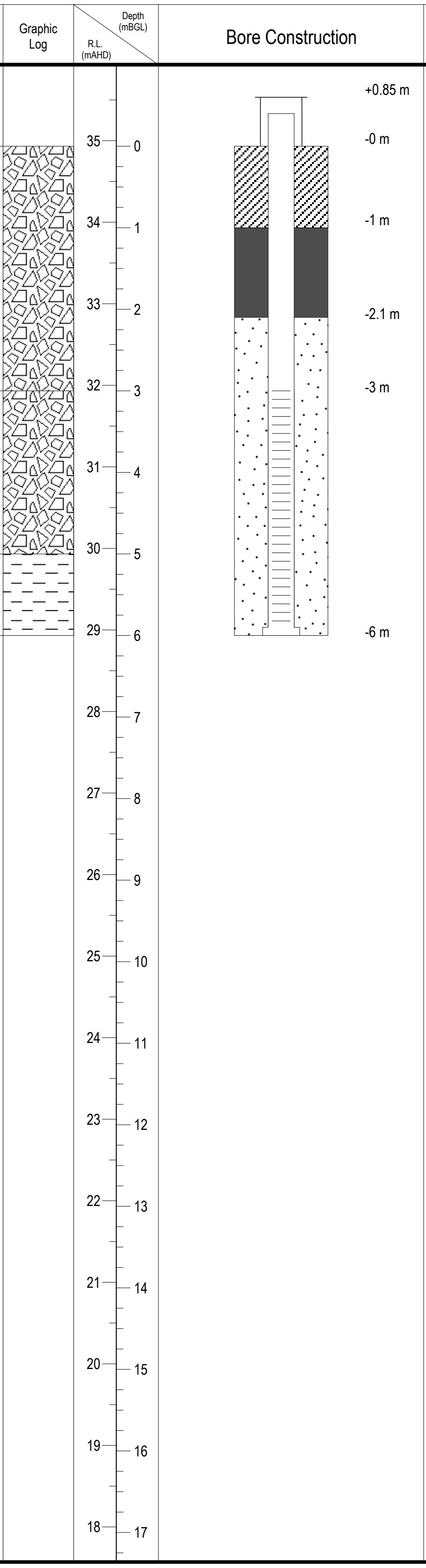
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **12/11/2017**
LOGGED BY: **L. Furness (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **583450.112 mE**
NORTHING: **8557842.787 m**
DATUM: **GDA 94 Z 55**
RL: **34.932 mAHD**
TD: **6 mBGL**

COMMENTS:

Soil or Rock Field Material Description	
Bauxite	SILTY PISOLITIC BAUXTITE: clayey texture, red.
	SILTY CLAY: red.
Weathered Bulimba Fm	CLAY: Orange



Bore Description

Protective lockable steel collar
PVC Stick up: +0.85 m

Grout [5 % bentonite] : 0 m to 1 m

150 mm [Tungsten chip drill bit]: 0 m to 6 m (Sonic)

Bentonite seal: 1 m to 2.1 m

50 mm uPVC blank casing: 0 m to 3 m

3 - 6 mm washed, rounded, quartz gravel pack: 2.1 m - 6 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 3 m to 6 m

Bore dry at time of construction

End cap

End of hole: 6 m BGL

BOREHOLE LOG

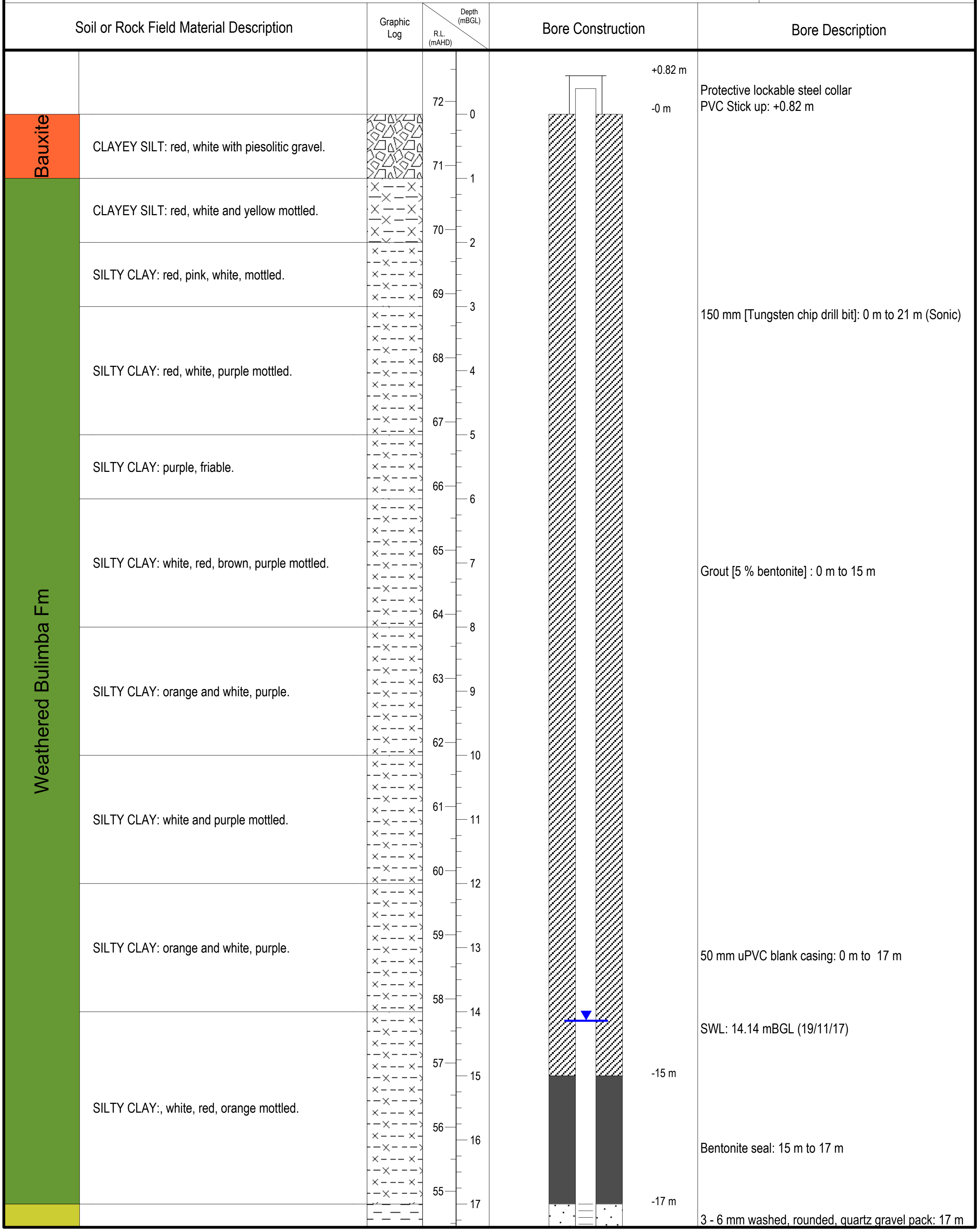
C_MB10A

PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **14/11/2017**
LOGGED BY: **L. Furness (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **591967.956 mE**
NORTHING: **8566214.213 m**
DATUM: **GDA 94 Z 55**
RL: **71.8 mAHD**
TD: **21 mBGL**

COMMENTS:



	Soil or Rock Field Material Description
Bauxite	CLAYEY SILT: red, white with piesolitic gravel.
Weathered Bulimba Fm	CLAYEY SILT: red, white and yellow mottled.
	SILTY CLAY: red, pink, white, mottled.
	SILTY CLAY: red, white, purple mottled.
	SILTY CLAY: purple, friable.
	SILTY CLAY: white, red, brown, purple mottled.
	SILTY CLAY: orange and white, purple.
	SILTY CLAY: white and purple mottled.
	SILTY CLAY: orange and white, purple.
	SILTY CLAY:, white, red, orange mottled.

Bore Construction

Bore Description

Protective lockable steel collar
PVC Stick up: +0.82 m

150 mm [Tungsten chip drill bit]: 0 m to 21 m (Sonic)

Grout [5 % bentonite] : 0 m to 15 m

50 mm uPVC blank casing: 0 m to 17 m

SWL: 14.14 mBGL (19/11/17)

Bentonite seal: 15 m to 17 m

3 - 6 mm washed, rounded, quartz gravel pack: 17 m

BOREHOLE LOG

C_MB10A

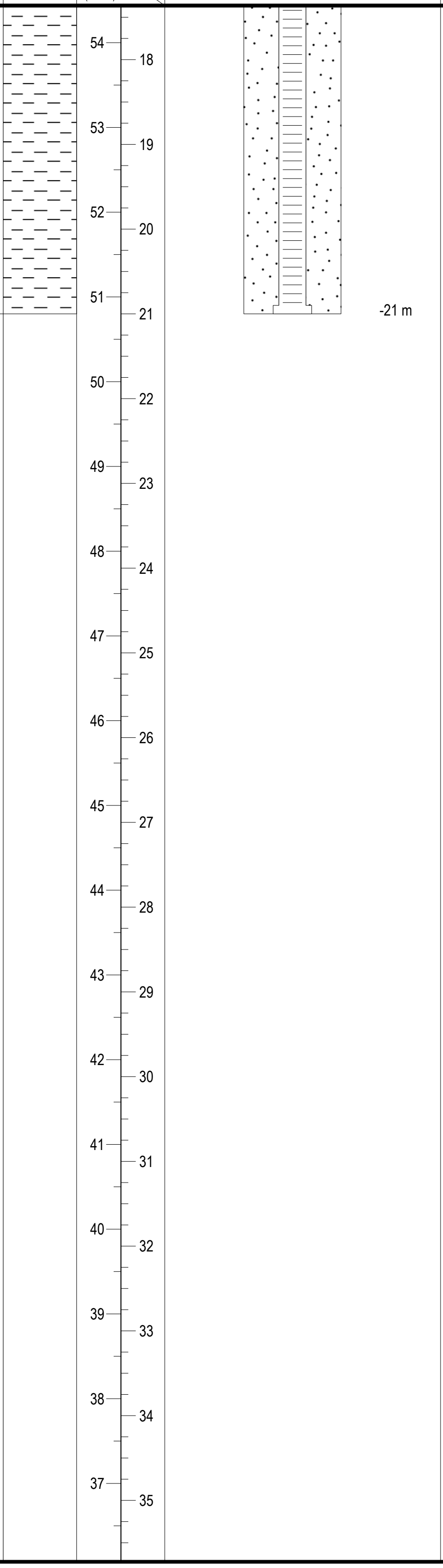
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **14/11/2017**
LOGGED BY: **L. Furness (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **591967.956 mE**
NORTHING: **8566214.213 m**
DATUM: **GDA 94 Z 55**
RL: **71.8 mAHD**
TD: **21 mBGL**

COMMENTS:

Soil or Rock Field Material Description		Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
Bulimba Fm	SILTSTONE: purplish to roange. [BULIMBA FM]				- 21 m 50 mm uPVC machine slotted casing, slot aperture: 1 mm, 17 m to 21 m End cap End of hole: 21 m BGL



BOREHOLE LOG

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C_MB10B

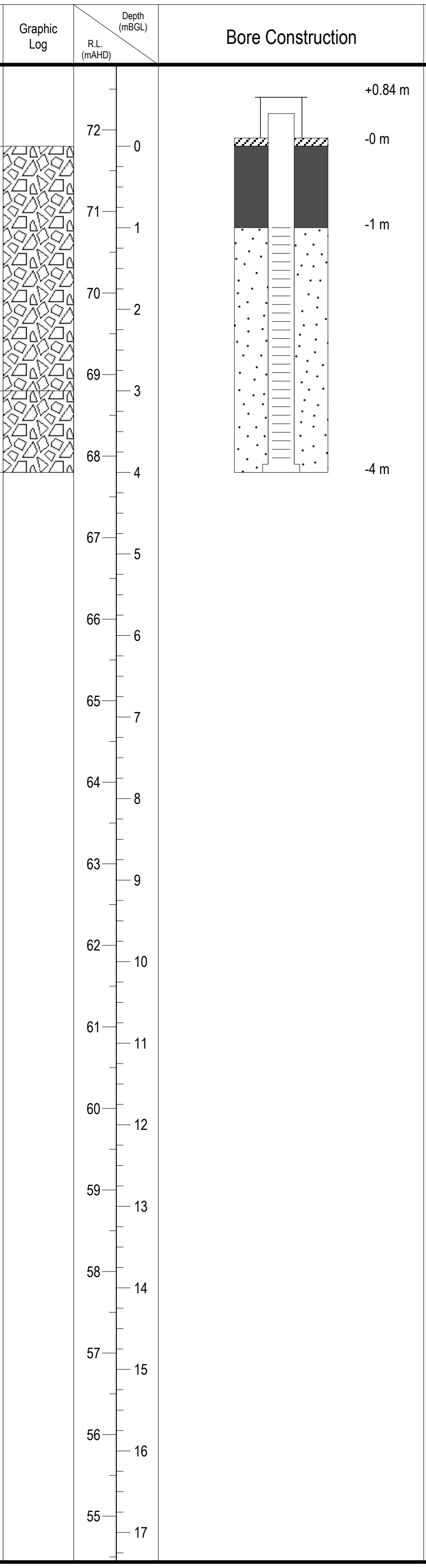
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **14/11/2017**
LOGGED BY: **L. Furness (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **591967.113 mE**
NORTHING: **8566217.972 m**
DATUM: **GDA 94 Z 55**
RL: **71.8 mAHD**
TD: **4 mBGL**

COMMENTS:

Soil or Rock Field Material Description	
Bauxite	SILTY CLAY: red and white, mottled.
	CLAYEY SILT: red, pisolitic.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.84 m

Grout [5 % bentonite] : Surface

Bentonite seal: 0 m to 1 m

150 mm [Tungsten chip drill bit]: 0 m to 4 m (Sonic)

50 mm uPVC blank casing: 0 m to 1 m

Bore dry at time of construction
3 - 6 mm washed, rounded, quartz gravel pack: 1 m - 4 m
50 mm uPVC machine slotted casing, slot aperture: 1 mm, 1 m to 4 m

End cap

End of hole: 4 m BGL

Australasian Groundwater & Environmental Consultants Pty Ltd
Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

C_MB11A

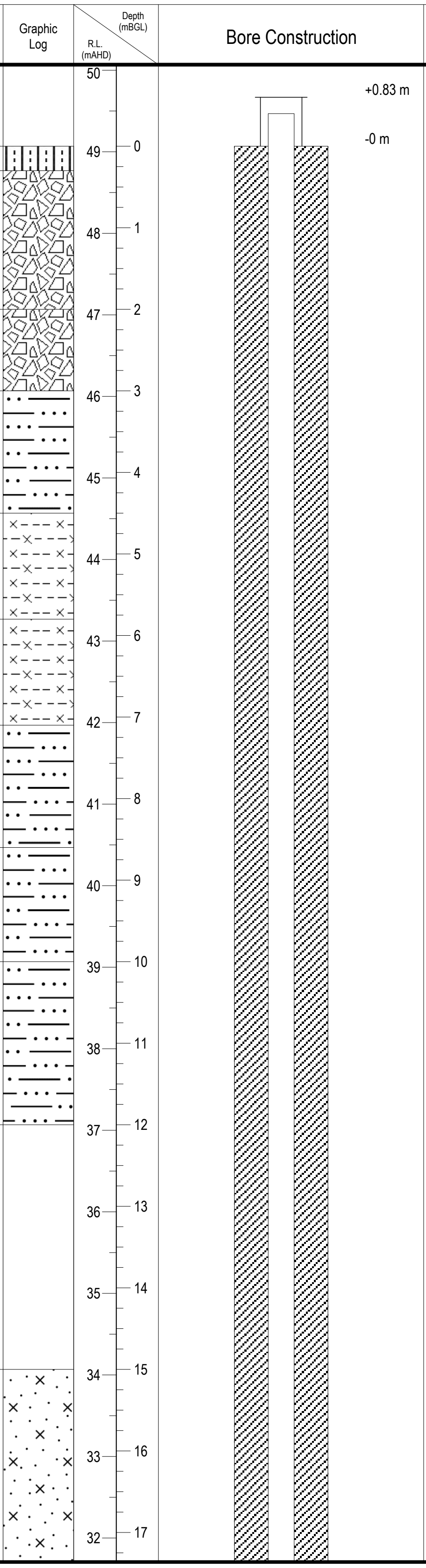
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **17/11/2017**
LOGGED BY: **L. Furness (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **580747.033 mE**
NORTHING: **8562671.941 m**
DATUM: **GDA 94 Z 55**
RL: **49.068 mAHD**
TD: **33 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Soil	SOIL: light brown, moist.
Bauxite	SILTY SAND: light brown with pisolitic gravel.
	GRAVELLY SAND: red piesolitic becoming sandy clay.
Weathered Bulimba Fm	SANDY CLAY: red and white.
	SILTY CLAY: pink.
	SILTY CLAY: pink and red.
	SANDY CLAY: pink and white.
	CLAYEY SAND: white and pink.
	SANDY CLAY: white and pink, with yellow mottling.
	NO SAMPLE.
	SILTY SANDSTONE: pink, yellow, white mottled.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.83 m

150 mm [Tungsten chip drill bit]: 0 m to 33 m (Sonic)

Grout [5 % bentonite] : 0 m to 26.9 m

50 mm uPVC blank casing: 0 m to 30 m

C_MB11A

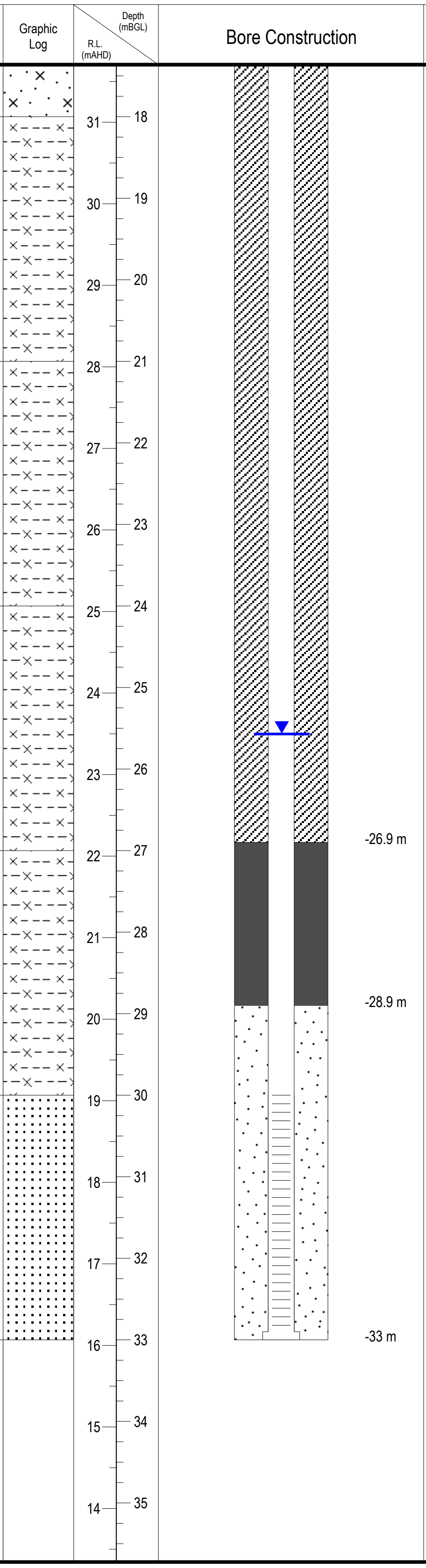
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **17/11/2017**
LOGGED BY: **L. Furness (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **580747.033 mE**
NORTHING: **8562671.941 m**
DATUM: **GDA 94 Z 55**
RL: **49.068 mAHD**
TD: **33 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Weathered Bulimba Fm	
	SILTY CLAY: white, slightly mottled, pink and grey.
	SILTY CLAY: white yellow purple mottled.
	SILTY CLAY: orange and white mottled.
	SILTY CLAY: orange mottled.
Bulimba Fm	SANDSTONE: orange, slightly fractured. [BULIMBA FM HW]



Bore Description

SWL: 25.57 mBGL (18/11/17)

Bentonite seal: 26.9 m to 28.9 m

3 - 6 mm washed, rounded, quartz gravel pack: 28.9 m - 33 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 30 m to 33 m

End cap
End of hole: 33 m BGL

Australasian Groundwater & Environmental Consultants Pty Ltd
Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

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C_MB11B

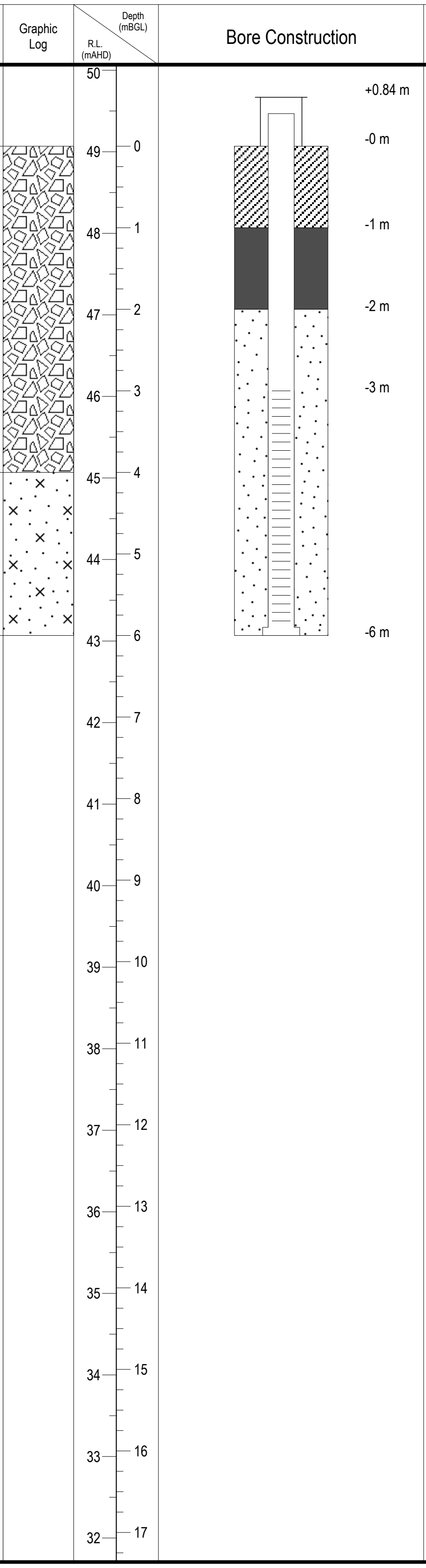
PROJECT No: **G1868C**
PROJECT NAME: **Coconut Project**
DATE DRILLED: **17/11/2017**
LOGGED BY: **L. Furness (AGE)**

DRILLING COMPANY: **Strategic Drilling Services**
DRILLER: **M. Hanlon (3403)**
DRILLING METHOD: **Sonic**
DRILL RIG: **TSi 150 CC**

EASTING: **580751.206 mE**
NORTHING: **8562675.58 mN**
DATUM: **GDA 94 Z 55**
RL: **49.068 mAHD**
TD: **6 mBGL**

COMMENTS:

	Soil or Rock Field Material Description
Bauxite	SILT: red, clayey, pisolites.
Weathered Bulimba Fm	SILTY SAND: red and white.



Bore Description

Protective lockable steel collar
PVC Stick up: +0.84 m

Grout [5 % bentonite] : 0 m to 1 m

150 mm [Tungsten chip drill bit]: 0 m to 6 m (Sonic)

Bentonite seal: 1 m to 2 m

50 mm uPVC blank casing: 0 m to 3 m

3 - 6 mm washed, rounded, quartz gravel pack: 2 m - 6 m

50 mm uPVC machine slotted casing, slot aperture: 1 mm, 3 m to 6 m

Bore dry at time of construction

End cap

End of hole: 6 m BGL