

Finniss Lithium Project

BP33 Groundwater

Modelling Report

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PREPARED FOR CORE EXPLORATION LIMITED
BY CLOUDGMS

CLOUDGMS PTY LTD
ABN 84 166 886 586

10 Hardy Street
Goodwood, SA 5034

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Authors

Anthony Knapton and Simon Fulton

CloudGMS Pty Ltd

ABN 84 166 886 586

10 Hardy Street, Goodwood

South Australia, 5034

Phone: 0428798665

Email: anthony.knapton@bigpond.com

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Abbreviations and acronyms

DENR	Department of Environment and Natural Resources
EoM	end of mining
GDE	groundwater dependant ecosystem
GIS	geographical information system
GL	gigalitre (10 ⁹ litres)
GLP	Grants Lithium Project
kL	kilolitre (10 ³ litres)
km	kilometre
km ²	square kilometre
L/s	litres per second
LoM	life of mine
m ² /d	metres squared per day
m ² /d	metres squared per day
m ³	cubic metre
m ³ /d	cubic metres per day
m ³ /s	cubic metres per second
ML	megalitre (10 ⁶ litres)
ML/a	megalitre per year
mAHD	metres above Australian Height Datum
mBGL	metres Below Ground Level
mm	millimetre
mm/d	millimetre per day
pF	log scale for representing soil matric potential
RMS	root mean square
SRMS	scaled root mean square
SRTM	Shuttle Radar Topographic Mission
T	Transmissivity (metres squared per day)
WRD	waste rock dump

1 Introduction

1.1. Background

Core Lithium Limited (Core) is proposing to expand its planned Finnis Lithium Project mining activities on the Cox Peninsula, 33 km west of Berry Springs. Core currently holds mining authorisation for an open pit mine and processing of the Grants resource on Mineral Lease (ML) 31726; referred to as Grants Lithium Project (GLP). Core is also proposing to develop an underground mine at the BP33 resource, located approximately 4.5 km south-east of the Grants pit. The BP33 project will involve the underground mining of ore and trucking to the Grants processing plant via a 7.5 km purpose-built haul road.

The action was referred to the NT Environment Protection Authority (NT EPA) for consideration under section 48 of the Environment Protection Act. In October, 2020, the NT EPA determined that the BP33 project should be assessed by the Supplementary Environmental Report (SER) process. The NT EPA direction outlined additional information requirements for the SER, including further detail on groundwater processes and impacts.

This report documents the development of conceptual and numerical groundwater models for the BP33 site and the use of these models to assess potential groundwater impacts. It also provides guidance on specific impacts, information and processes required under the SER direction.

1.2. Model Objectives

The objective of the BP33 groundwater model is to identify potential impacts to the groundwater system and associated environmental receptors resulting from the development of the proposed underground mine at BP33. The model also aims to assess any cumulative impacts resulting from the proposed open pit mine at the Grants deposit.

1.3. Modelling study scope of works and modelling process

The modelling study follows a staged approach in accordance with the 2012 Australian Groundwater Modelling Guidelines (Barnett, et al., 2012). A flow diagram of the modelling process is presented in Figure 1.1. The scope of the groundwater modelling study includes the following major components:

- Collation of available data for the BP33 and Grants site;
- Data review and conceptualisation of the groundwater system;
- Groundwater model design and configuration;
- Transient model development and calibration;
- Predictive scenario modelling to assess the potential for mining impacts;
- Predictive uncertainty analysis.

Mining activities at the GLP have been included in the modelling and calibration process in order to assess the cumulative impact from mining at the GLP and BP33. For detailed discussion of the proposed mining activities, site conceptualisation and model results for the GLP refer to CloudGMS (2018).

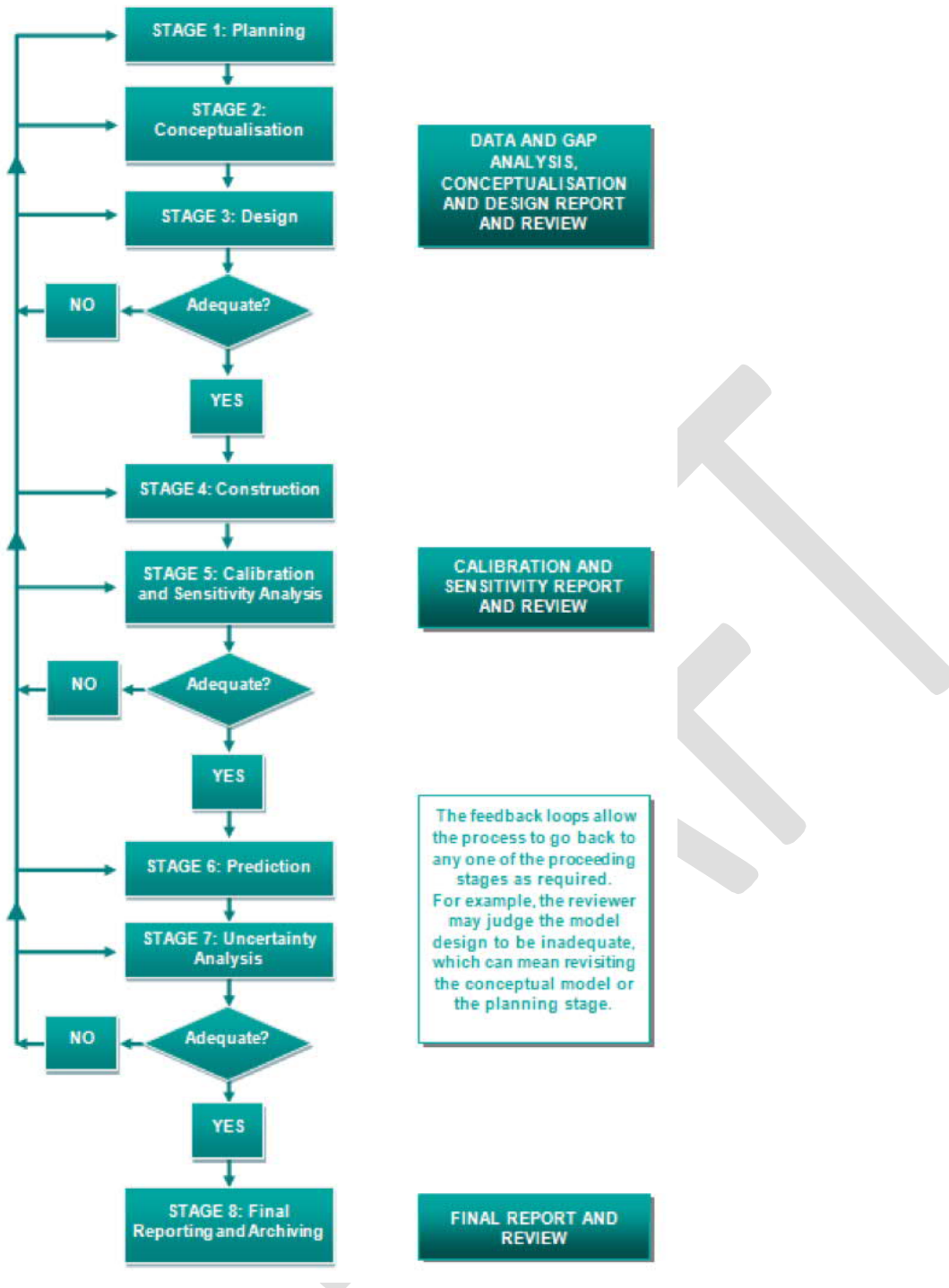


Figure 1 1 Groundwater modelling process after Barnett et al, (2012)

1.4. Model classification

Under the latest national best practice guidelines (Barnett, et al., 2012), the groundwater model presented is considered to be Class 2 with components that are Class 1 and Class 3. A Class 2 model is suitable for "providing estimates of dewatering requirements for mines and excavations and the associated impacts" (Barnett, et al., 2012). Table 1-1 identifies the classification criteria met by the current model.

Introduction

Table 1-1 Model classification criteria (after Barnett, 2012)

	Data	Calibration	Prediction	Key indicator	Example of use
Class 3	Spatial and temporal distribution of groundwater head observations adequately define groundwater behaviour, especially in areas of greatest interest and where outcomes are to be reported.	Scaled RMS error or other calibration statistics are acceptable.	Length of predictive model is not excessive compared to length of calibration period.	Key calibration statistics are acceptable and meet agreed targets.	Suitable for predicting groundwater responses to arbitrary changes in applied stress or hydrological conditions anywhere within the model domain.
	Spatial distribution of bore logs and associated stratigraphic interpretations clearly define aquifer geometry.	Long-term trends are adequately replicated where these are important.	Temporal discretisation used in the predictive model is consistent with the transient calibration.	Model predictive time frame is less than 3 times the duration of transient calibration.	Provide information for sustainable yield assessments for high-value regional aquifer systems.
	Reliable metered groundwater extraction data is available.	Seasonal fluctuations are adequately replicated where these are important.	Level and type of stresses included in the predictive model are within the range of those used in the transient calibration.	Stresses are not more than 2 times greater than those included in calibration.	Evaluation and management of potentially high-risk impacts.
	Rainfall and evaporation data is available.	Transient calibration is current, i.e. uses recent data.		Temporal discretisation in predictive model is the same as that used in calibration.	Can be used to design water-allocation plans.
	Aquifer-testing data to define key parameters.	Model is calibrated to heads and fluxes.		Mass balance closure error is less than 0.5% of total.	Simulating the interaction between groundwater and surface water bodies to a level of reliability required for dynamic linkage to surface water models.
	Good quality and adequate spatial coverage of digital elevation model to define ground surface elevation. Reliable land-use and soil-mapping data available.	Observations of the key modelling outcomes dataset is used in calibration.		Model parameters consistent with conceptualisation. Appropriate computational methods used with appropriate spatial discretisation to model the problem.	
Class 2	Groundwater head observations are available but may not provide adequate coverage throughout the model domain.	Calibration statistics are generally reasonable but may suggest significant errors in parts of the model domain(s).	Transient calibration over a short time frame compared to that of prediction.	Key calibration statistics suggest poor calibration in parts of the model domain.	Prediction of impacts of proposed developments in medium value aquifers.
	Bore logs are available but may not provide adequate coverage throughout the model domain.	Long-term trends not replicated in all parts of the model domain.	Temporal discretisation used in the predictive model is different from that used in transient calibration.	Model predictive time frame is between 3 and 10 times the duration of transient calibration.	Evaluation and management of medium risk impacts.

Introduction

Class 1	Metered groundwater-extraction data may be available but spatial and temporal coverage may not be extensive.	Transient calibration to historic data but not extending to the present day.	Level and type of stresses included in the predictive model are outside the range of those used in the transient calibration.	Stresses are between 2 and 5 times greater than those included in calibration.	Providing estimates of dewatering requirements for mines and excavations and the associated impacts.
		Seasonal fluctuations not adequately replicated in all parts of the model domain.		Temporal discretisation in predictive model is not the same as that used in calibration.	Estimating distance of travel of contamination through particle-tracking methods. Defining water source protection zones.
	Few or poorly distributed existing wells from which to obtain reliable groundwater and geological information.	No calibration is possible.	Predictive model time frame far exceeds that of calibration.	Model is uncalibrated or key calibration statistics do not meet agreed targets.	Design observation bore array for pumping tests.
	Observations and measurements unavailable or sparsely distributed in areas of greatest interest.	Calibration illustrates unacceptable levels of error especially in key areas.	Temporal discretisation is different to that of calibration.	Model predictive time frame is more than 10 times longer than transient calibration period.	Predicting long-term impacts of proposed developments in low-value aquifers.
	No available records of metered groundwater extraction or injection.	Calibration is based on an inadequate distribution of data.	Transient predictions are made when calibration is in steady state only.	Stresses in predictions are more than 5 times higher than those in calibration.	Estimating impacts of low-risk developments.
	Climate data only available from relatively remote locations.	Calibration only to datasets other than that required for prediction.	Model validation* suggests unacceptable errors when calibration dataset is extended in time and/or space.	Stress period or calculation interval is different from that used in calibration.	Understanding groundwater flow processes under various hypothetical conditions.
Little or no useful data on land-use, soils or river flows and stage elevations.			Transient predictions made but calibration in steady state only.	Provide first-pass estimates of extraction volumes and rates required for mine dewatering.	
			Model parameters outside the range expected by the conceptualisation with no further justification.	As a starting point on which to develop higher class models as more data is collected and used.	
			The model has not been reviewed.		

Criterion met.	Criterion met by current model study at the relevant class
Criterion met through higher model classification.	Criterion met in higher class
Criterion partially met.	Criterion not met by current model study

2 Site Characterisation

2.1. Location

The BP33 project is located 2.5 km south-west of the Cox Peninsula Road and approximately 33 km west of the Berry Springs township (see Figure 2-1). Two mineral leases (ML32074 and ML32346) cover the BP33 project area. The leases cover a combined area of 848 ha of vacant crown land. The proposed mining infrastructure at the BP33 project will extend over 7.2% (61.4 ha) of the combined mining lease.

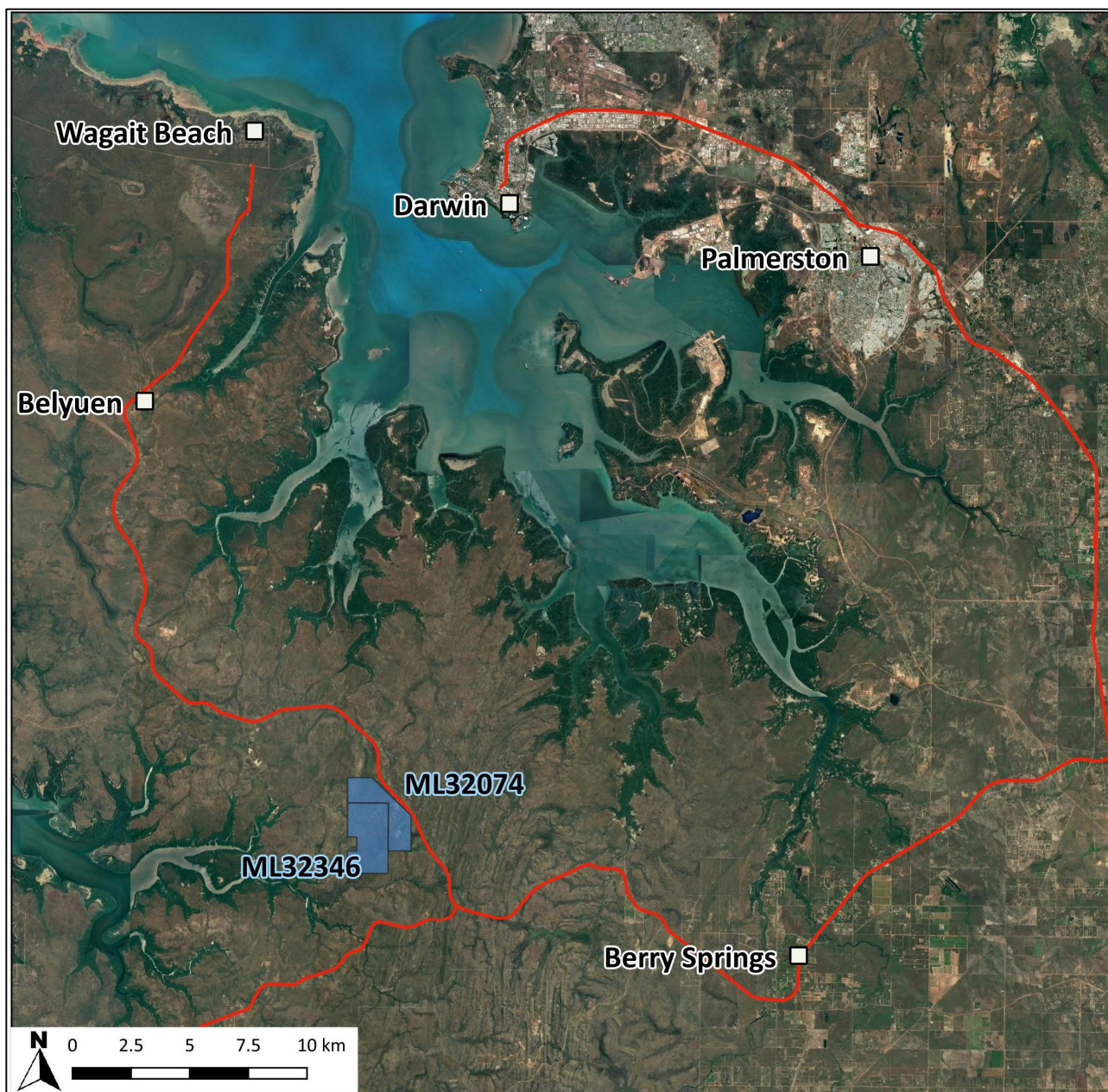


Figure 2-1 Location of the BP33 project

2.2. Climate

Climate data for the BP33 study area has been sourced from SILO data drill (<https://www.longpaddock.qld.gov.au/silo>), a national scale database of climate records for

Available Data

Australia. The SILO data set has been used in preference to individual weather stations in the Darwin area because it provides a continuous rainfall and evaporation record for the study. The SILO data site was located at Latitude, Longitude: -12.70 130.80 (Decimal Degrees).

The study area has an average annual rainfall of 1530 mm and average annual potential evaporation of 2280 mm. Average maximum temperature ranges from 34.4 degrees Celsius (°C) in October to 30.9°C in June and July (Figure 2-2a). July is the coolest month with an average minimum temperature of 17.9°C. Rainfall is concentrated in the wet season with around 90% of precipitation occurring between November and March. January is the wettest month with an average rainfall total of 382 mm. Peak potential evaporation occurs between September and October, with potential evaporation being lowest during February and March (Figure 2-2b). Average monthly rainfall only exceeds potential evaporation during the wettest months (December-March). The rainfall data is presented in Figure 2-3 as annual totals with a trace of the cumulative rainfall residual which shows long-term trends in the rainfall record.

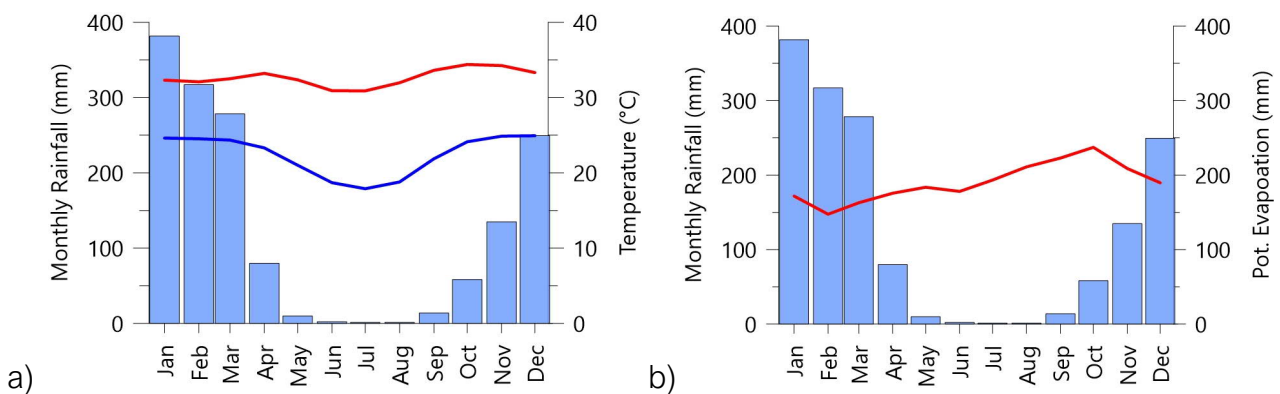


Figure 2-2 (a) Average monthly rainfall compared to average max and min temperatures and (b) average monthly rainfall compared to monthly potential evaporation for the period 1900-2020 (SILO Data Drill).

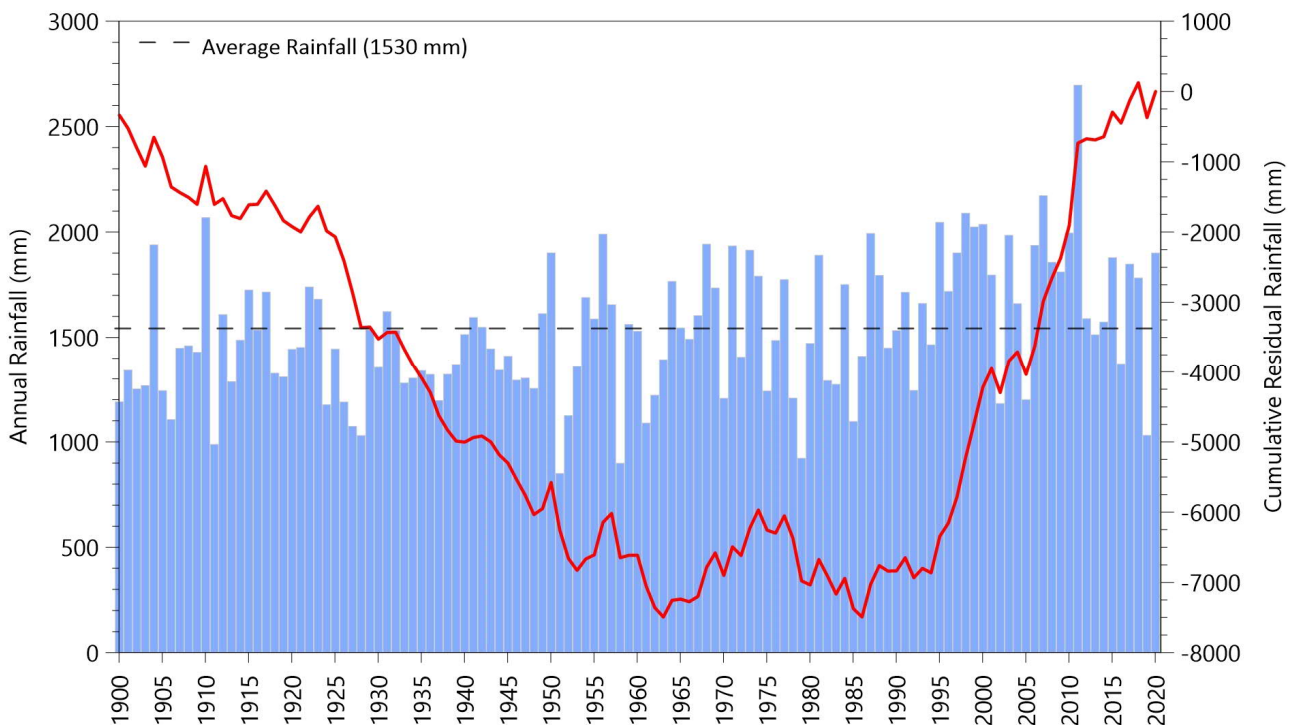


Figure 2-3 Annual rainfall totals with a trace of mass residual rainfall (1900-2020).

2.3. Topography and Drainage

The regional topography surrounding the BP33 site is largely subdued and flat lying. Locally BP33 is situated in a subtle valley with a south to south-west orientation (Figure 2-4). Higher elevations (40 mAHD) occur to the north-east around Observation Hill Dam (OHD). This elevated area extends to the north-west and forms a catchment divide that separates the BP33 site from the proposed GLP, located 4.5 km to the north-west. The land surface falls away from the BP33 site to the south-west with the lowest lying areas (10 mAHD) found along drainage lines running into Bynoe Harbour.

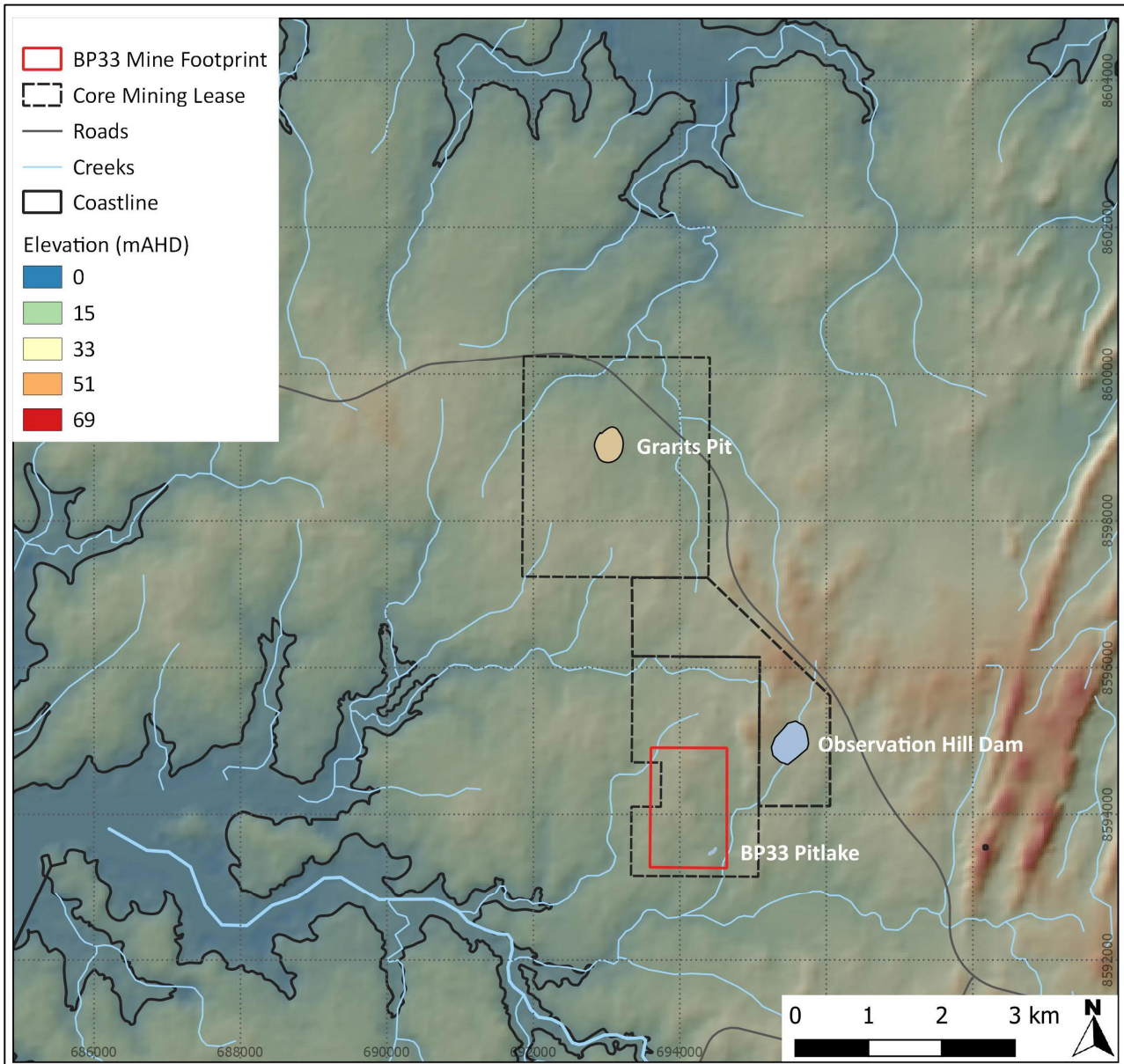


Figure 2-4 Topography of the study area with surface water drainage

BP33 is located in the Finnis River drainage basin and falls within the Bynoe Harbour catchment. There are no permanent water courses in the vicinity of BP33. The area is drained by a number of small unnamed ephemeral water courses which rise in the higher elevations to the north-west of BP33 and drain south-west into the Charlotte River and ultimately Bynoe Harbour. BP33 is located on the western edge of a small drainage line that connects OHD to

the Charlotte River. The BP33 site contains a small pre-existing pit-lake, which is a remnant of mining activities from the early 1990s. Both OHD and the BP33 pit lake contain surface water that typically persists through the dry season. While OHD is fed by a drainage line, BP33 is not connected to any channels and the water present in the pit is likely to represent a groundwater feature.

The generalised topography and drainage around the BP33 site are shown in Figure 2-4. Topographic data is derived from two sources: a LIDAR survey and the National Digital Elevation Model (DEM). The LIDAR survey data extends across the three mining tenements (ML31726, ML32074, ML32346) that encompass the Grants and BP33 projects. For areas within the model domain outside the mining tenements the LIDAR data has been merged with National scale 1 Second Hydrologically Enforced Digital Terrain Model (DTM), derived from the National DEM SRTM 1 Second and National Watercourses, Lakes and Reservoirs. (<http://www.ga.gov.au/elvis/>). The Shuttle Radar Topography Mission (SRTM) Digital Terrain Elevation Data (DTED) are used with the consensus view that it has a minimum vertical accuracy of 9 m absolute error at 90% confidence world-wide and the minimum vertical accuracy for Australia is 6m (Farr, et al., 2007).

2.4. Geology

BP33 is located in the north-west of the Pine Creek Geosyncline, a thick sequence of Proterozoic metasediments that overlies Archean basement rocks and underwent extensive folding and uplift around 1800 million years ago. After a long hiatus during which significant weathering and erosion occurred a drape of flat bedded Cretaceous and Cainozoic sedimentary formations were deposited over the Proterozoic rocks.

The lithium prospect at BP33 is hosted in a pegmatite, which is one of a swarm of complex zoned rare element pegmatites forming the 55 km long by 10 km wide West Arm–Mt Finnis pegmatite belt. The Finnis pegmatites are intruded into the early Proterozoic Burrell Creek Formation (BCF) which is distributed along the northwest margin of the Pine Creek Geosyncline. The BP33 pegmatite is north-east trending and steeply dipping, it is approximately 75 m long with a width of between 25 – 40 m (Frater, 2005). From exploration drilling the top of the BP33 pegmatite ranges in depth from 30 – 180 m below surface, with an average depth of 90 m.

The BCF is comprised of shale, siltstone, sandstone and strongly foliated phyllite with lenses of quartz pebble conglomerate. The formation is extensively weathered at surface where it often forms a laterite horizon. The underlying shale and phyllite is typically heavily weathered and decomposed into mottled clay. Exploration drilling at BP33 indicates the weathered zone is on average 60 m thick with the upper 30 m typically showing extensive weathering and the bottom 30 m showing moderate to slight weathering.

Where the BCF is not exposed it subcrops beneath a thin veneer of Tertiary and Quaternary aged sediments. These include alluvial deposits (Qa) along the drainage lines as well as colluvium (Cz) and laterite formed by in-situ weathering of the BCF. The colluvium comprises ferruginous clayey, sandy and gravelly soils. Both the colluvium and laterite deposits are typically less than 4 m in thickness (Pietsch, 1986).

The alluvial deposits centre around active drainage lines and can extend up to several kilometres in length and up to 200-300 m in width (Frater, 2005). They are typically less than 4 m in thickness but can exceed 6 m in the southern sections of the Booths drainage

Available Data

(Mollemans and Hatcher, 1988) - Booths is the drainage line running south from Observation Hill dam to the immediate east of BP33. Mollemans and Hatcher (1988) describes the following three sedimentary layers in alluvial deposits around BP33/Observation Hill area:

- A-layer: Less than 0.5 m thick and may contain a thin band of pebbles (5–10 mm wide) at its base. It is essentially un-mineralised and is capped by an organic clay layer.
- B-layer. A minor gravel layer up to 1 m thick, directly overlying the C-layer or separated from it by thin bands of clayey sand.
- C-layer. This earliest layer consists of basal clayey sand or gravel up to 2.5 m thick, containing sub-angular quartz and siltstone clasts up to 200 mm in length.

Mollemans and Hatcher (1988) note that in some areas the alluvial deposits have been completely reworked with black soil, and that the bedrock under the main alluvial channel is typically heavily weathered. The 1:250 000 scale surface geology for the study area and surrounding region is presented in Figure 2-5.

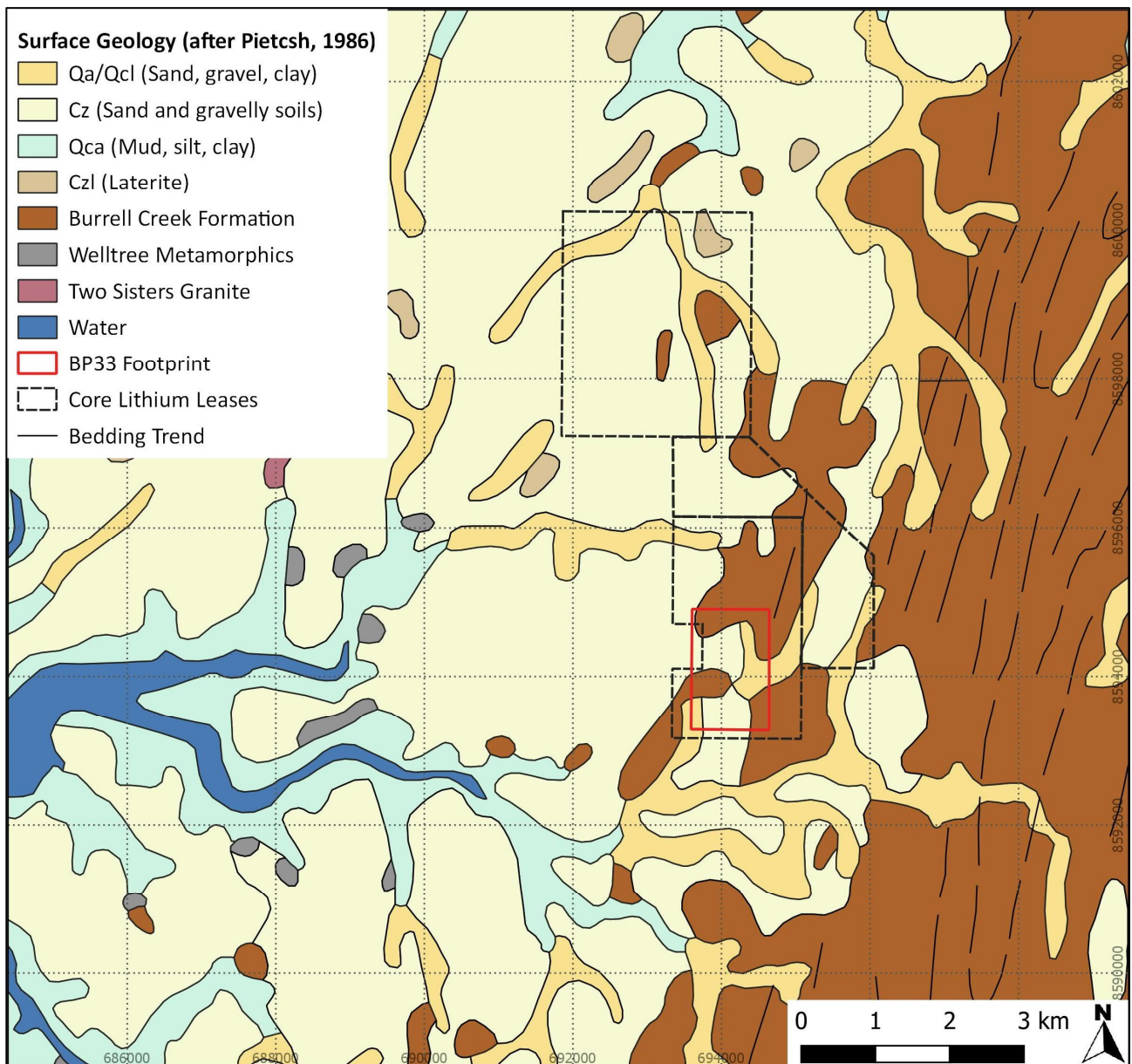


Figure 2-5 Surface geology derived from the 1:250000 scale geology coverage.

2.4.1. Geological structure

Phyllite is a foliated rock, and based on the discussion with Core personnel, it is understood that the foliation is striking approximately North-South (~010-015°). This is consistent with bedding trends mapped in outcropping BCF in regional geological maps (Figure 2-5).

A review of the Bynoe 1:100 000 surface geology (Pietsch, 1986) did not reveal any mapped faults or significant geological structures in the vicinity of the BP33 project area.

2.5. Hydrogeology

The BCF forms the main aquifer beneath the BP33 site. It is a marginal fractured rock aquifer with typical bore yields of less than 0.5 L/s; largely due to the low primary porosity and lack of open fracturing within the formation. Higher yields (up to 3.5 L/s) have been recorded where drilling intersects fracture zones or bands of quartz veining. These fracture zones are discrete and commonly less than 1 m in thickness. Groundwater is typically intersected at the base of the weathering zone/transition into fresh BCF. Groundwater drilling around the BP33 site indicates the main groundwater intersections occur at depths of 25 – 70 m with most bores intersecting the groundwater at depths around 45 m. The BCF is largely fine grained and characteristically weathers to clay. Where heavily weathered the formation is likely to be less permeable relative to fresh rock due to the higher likelihood of fractures staying open in the more competent, unweathered rock.

There is limited information available on the groundwater characteristics of the pegmatite. Anecdotal information from mineral drilling and diamond coring at BP33 suggests the pegmatite is very competent and has limited potential to form an aquifer. The pegmatite is an igneous rock with negligible primary porosity and aquifer development is dependent on fracturing. Geotechnical logging at BP33 suggests the fracture density within the pegmatite is of a similar order to the surrounding BCF.

There is potential for minor aquifers in the Cenozoic deposits (sand, clay, gravel and laterite) in areas with thicker alluvial cover (i.e. along drainage lines) or where the laterite profile is more extensive. Investigation drilling undertaken at BP33 in late 2020 found that the alluvial sediments have limited spatial extent and thickness (< 4.5 m). In the late dry season the alluvial sediments were unsaturated at the drilling sites between the BP33 pit/proposed mine workings and the drainage line to the east. These results and subsequent groundwater monitoring suggest groundwater within the alluvial deposits is largely ephemeral or is restricted to small areas in very close proximity to the drainage lines.

2.5.1. Previous studies

A preliminary groundwater investigation at the BP33 was undertaken in 2020 (Groundwater Enterprises, 2020a). The investigation involved the installation of 13 dedicated monitoring bores at seven locations around BP33. Nested bores were constructed at five sites to investigate the occurrence of shallow groundwater within alluvial deposits and the weathered top of the BCF, and its connection to the deeper, fractured rock aquifer in the BCF. Hydraulic testing (slug testing) was undertaken on all constructed bores. Monitoring of groundwater levels commenced in October 2020 with pressure loggers installed in all monitoring bores and also the BP33 pit-lake. Groundwater sampling has been undertaken at a monthly interval to collect a baseline groundwater quality data set for the aquifers at the BP33 site.

Available Data

In addition to the BP33 groundwater investigation two phases of groundwater drilling have been undertaken at the GLP. A preliminary groundwater investigation was undertaken by GHD in 2017 (GHD, 2017). The investigation program involved the drilling and construction of six monitoring bores, hydraulic testing (recovery and slug tests) and water quality sampling. In 2020, five additional monitoring bores were installed at GLP in accordance with requirements under the environmental approvals process (Groundwater Enterprises, 2020b). Water level monitoring and groundwater sampling is currently undertaken monthly on these bores. The location of the BP33 and Grants monitoring bores is shown in Figure 2-6.

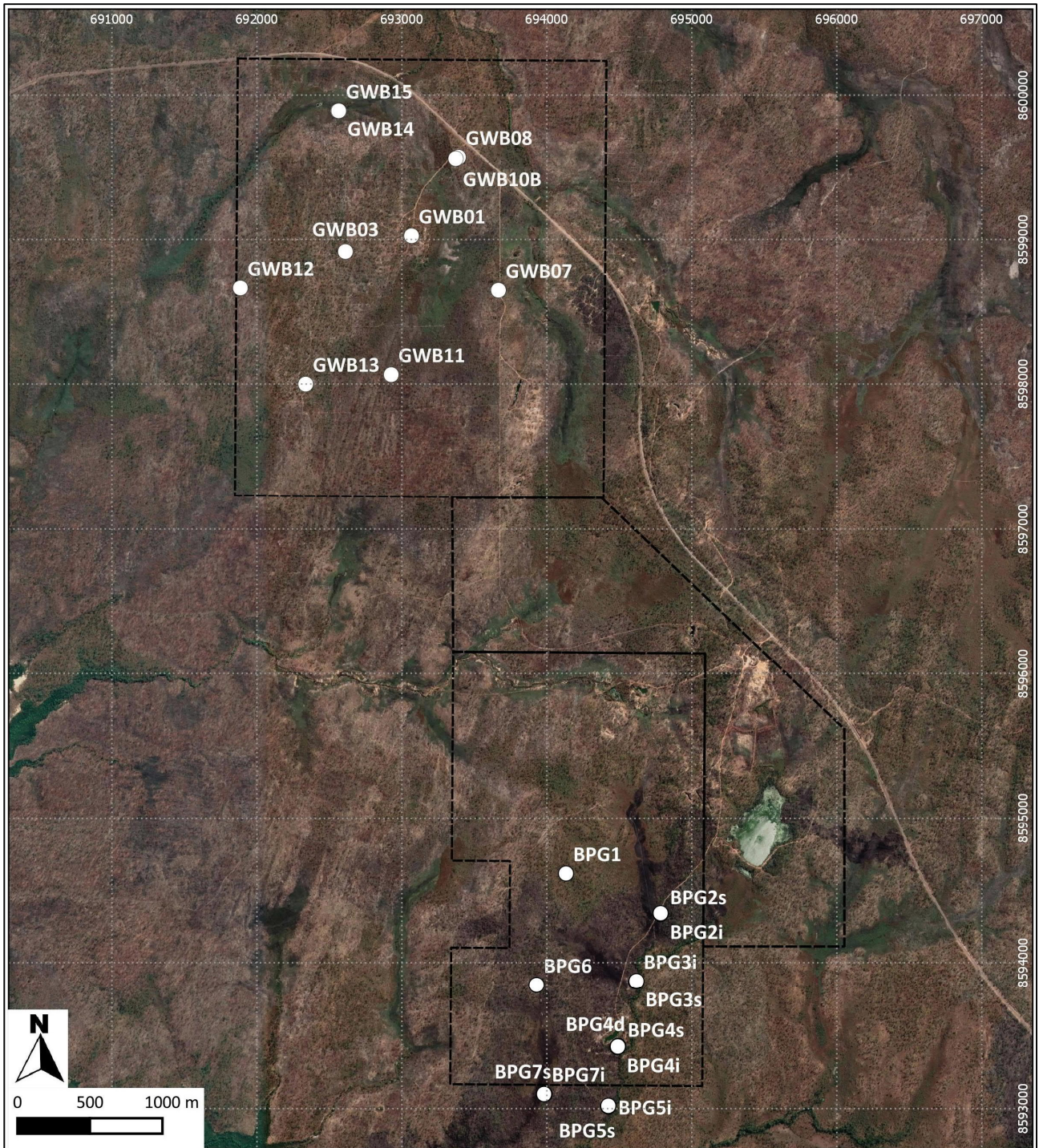


Figure 2-6 Location of GLP and BP33 monitoring bores on Core Lithium's mining leases

The BP33 project falls within regional hydrogeological and water resource mapping completed by the Water Resources Division on the Bynoe 1:100 000 map sheet in 2004 and the Cox Peninsula in 2008 (DIPE, 2004; NRETA, 2008). There are several groundwater investigations in the Greater Darwin region that provide context on groundwater occurrence in the BCF, these include:

- Karp (2010) - In 2010 the current DEPWS Water Resources Division reported on results from investigation drilling conducted in the BCF near the proposed city of Weddell (Karp, 2010). They report a yield range of < 0.1 – 2 L/s (median 0.3 L/s) from seven investigation bores constructed in the BCF. All bores encountered groundwater within fractured and weathered rocks at the base of the weathering zone. Although two bores recorded yields of 2 L/s, Karp (2010) suggests that 0.5 L/s is more characteristic of the longer-term yield for bores constructed in the BCF.
- Karp (2009) – Water Resources Division completed a groundwater investigation in the suburbs of Johnston and Zuccoli to assess water potential in the area. Six bores were drilled targeting a quartz ridge within the BCF (shown as Acacia Gap Quartzite on the geology maps), airlift yields ranged from < 0.1 – 9 L/s. The investigation identified a narrow aquifer associated with the fractured quartz ridge, elsewhere only minor and localised aquifers were intersected in siltstones of the BCF.
- Verma (1982) – Water Resources Division completed a groundwater investigation on the Cox Peninsula to the north-west of the BP33 site between 1979 and 1982. The study involved a geophysics and investigation drilling program. Two minor aquifers were identified: a shallow aquifer in the Bathurst Island Formation (Cretaceous) which extended into the weathering zone of the underlying Proterozoic rocks and a deep structurally controlled aquifer in the Proterozoic Formations. Bore yields ranged from 0.1 – 1.5 L/s indicating the aquifers have poor water supply potential. The marginal nature of the aquifers is consistent with groundwater drilling observations from Proterozoic rocks (BCF) at the BP33 site.
- Inpex EIS Hydrology and Hydrogeology of Blaydin Point (2009) – URS completed detailed groundwater investigations on the Inpex Gas site at Blaydin point and drilled around 10 investigation bores into the BCF. All bores were constructed to screen the shallower Cenozoic and Cretaceous sediments so hydraulic testing and monitoring results have limited application to the BP33 site.

2.5.2. Previous groundwater modelling studies

A numerical groundwater model was developed to investigate the impact of proposed mining at the GLP on the surrounding aquifer system (CloudGMS, 2018). This work was undertaken to support the Environmental Impact Statement for the GLP. The current groundwater model at BP33 encompasses the GLP model domain and features in order to assess the cumulative impacts from the broader lithium mining project.

No other published groundwater modelling studies have been identified that cover the project area.

2.5.3. Hydrostratigraphic units

The geological formations within the study area have been combined into three hydrostratigraphic units (HSU) for inclusion in the groundwater model. An HSU is a geological

Available Data

formation or part of a formation with similar hydrogeological properties or characteristics. The hydrostratigraphic units defined for the BP33 project are presented below in Table 2-1.

Table 2-1 Hydrostratigraphic units

Age	Name	Lithology	Hydrogeology	HSU
Quaternary	Alluvial sediments	Silty sand and gravels	Permeable, but mostly above water table.	
Proterozoic	Highly to moderately weathered BCF	Saprolite (Phyllite) Mostly silt, clayey and minor sand.	Mostly low permeability.	1
Proterozoic	Slightly weathered BCF	Saprock (Phyllite) mostly clayey silt with rock fragments.	Mostly low permeability. A few fractured aquifers, but yields typically less than 2 L/s.	2
Proterozoic	Fresh BCF	Blue grey fresh Phyllite.	Low permeability, locally fractured rock.	3

The HSUs have been incorporated into a hydrostratigraphic model which was developed using the Leapfrog Hydro geological modelling software. Leapfrog Hydro provides a flexible platform for incorporating lithological information and generating hydrostratigraphic contacts from a variety of sources including surface geological mapping, lithological logs and surfaces generated from geophysical surveys. Each HSU in the Leapfrog model is represented as a three-dimensional object that can be continuous or discontinuous within the model domain. The hydrostratigraphic model forms the basis of FEFLOW model grid geometry, this is discussed further in Section 4.3.

2.5.4. Aquifer hydraulic properties

AQUIFER TRANSMISSIVITY / HYDRAULIC CONDUCTIVITY

Thirteen monitoring bores were constructed on site in 2020 with six bores constructed in fractured slightly weathered to fresh BCF (HSU2), five bores constructed in heavily weathered to fresh BCF with negligible fracturing (HSU3) and two bores constructed in alluvial sediments. Slug tests were completed on the installed monitoring bores, hydraulic conductivity results from Groundwater Enterprises (2020) are summarised in Table 2-2.

Table 2-2 Summary of monitoring bore hydraulic conductivity test results at BP33

SCREENED FORMATION	NO. BORES	K MIN (m/day)	K MAX (m/day)	K GEOMETRIC MEAN (m/day)
Burrell Creek Formation Fresh-weathered <i>Negligible fracturing</i>	5	0.003	0.08	0.03
Burrell Creek Formation Fresh-weathered <i>Fractured</i>	5	0.27	2.6	1.0
Alluvial Deposits (silty sand)	1	0.4	0.4	-

The test results reveal that the permeability of the BCF is dependent on secondary porosity (i.e., fracture and joint development). Fresh and weathered BCF with negligible fracturing displayed a hydraulic conductivity range of 0.003 – 0.08 m/day. Bores that intersected

Available Data

fractured BCF (fresh or weathered) showed a hydraulic conductivity two orders of magnitude higher with a range from 0.27 – 2.6 m/day. The alluvial sediments (silty sand) tested with a hydraulic conductivity in the order of 0.4 m/day.

STORAGE COEFFICIENTS

Specific yield is defined as the volume of water that will drain under gravity from a unit volume of rock over a long period of time. The specific yield is best estimated from the response to long-term pumping, however, no such information is available for the BCF. Values typical of weathered and fractured rocks have been adopted (0.01-0.02), these are consistent with values adopted for the numerical modelling of the Mt Todd Gold Project (GHD, 2013) which is also located in the Pine Creek Geosyncline and models the Burrell Creek Formation.

2.5.5. Depth to Groundwater and Water Level Fluctuation

Groundwater level monitoring has been undertaken on the BP33 bores since their installation in the dry season of 2020. Groundwater levels in the deeper fractured BCF bores ranged from 4.5 to 9.8 mBGL in the late dry season (Figure 2-7). The bores responded uniformly to wet season recharge and groundwater levels approached land surface by late January 2021. The seasonal change in water levels in the deep BCF bores ranges from 3.7 – 9.6 m. The seasonal range is greatest in BPG1 and BPG6. These bores are located on a ridge of outcropping BCF approximately 15 m higher in the landscape than the other bore sites. The larger water level range in these bores suggests that recharge rates may be higher in the elevated areas relative to the lower lying sites along the drainage lines. The water level range observed in 2020 is consistent with the longer monitoring record available from bores at GLP (Figure 2-8). Since 2018 the annual change in groundwater levels in the deep BCF bore GWB3 at the GLP has ranged from 5.4 – 9.3 m.

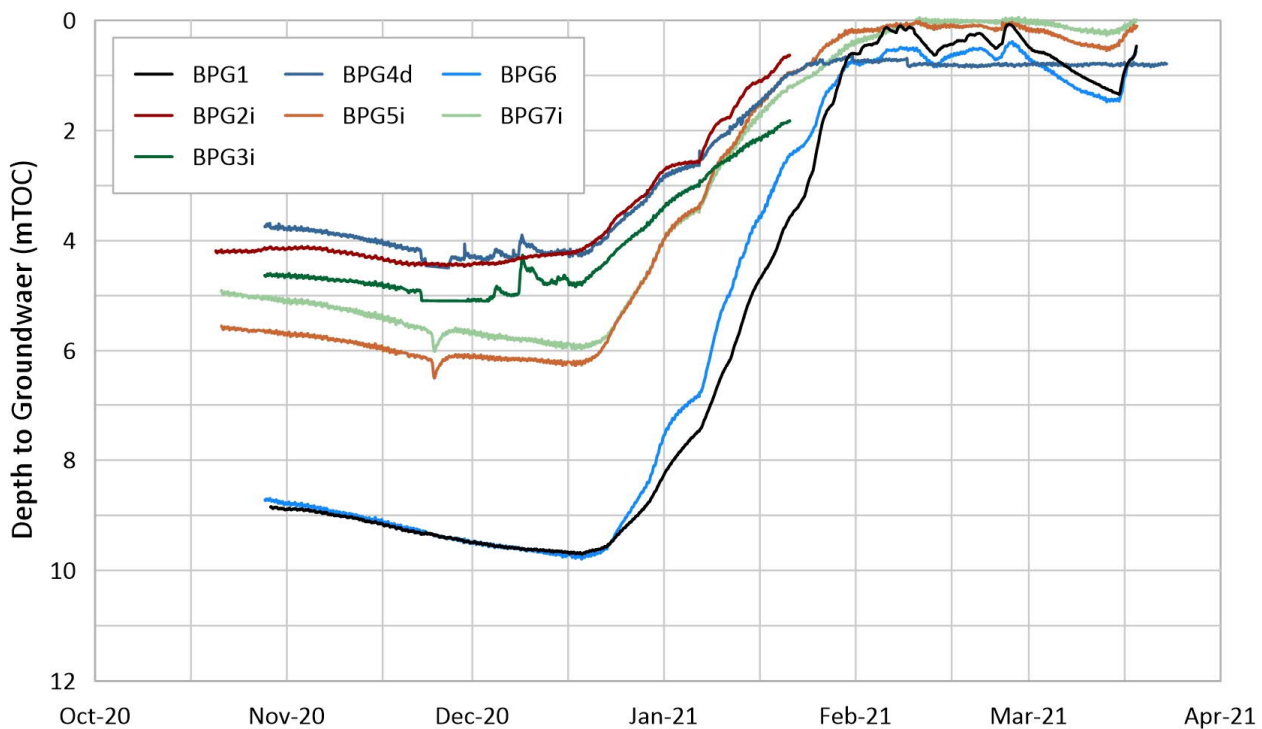


Figure 2-7 Hydrographs for BP33 Deeper Bores

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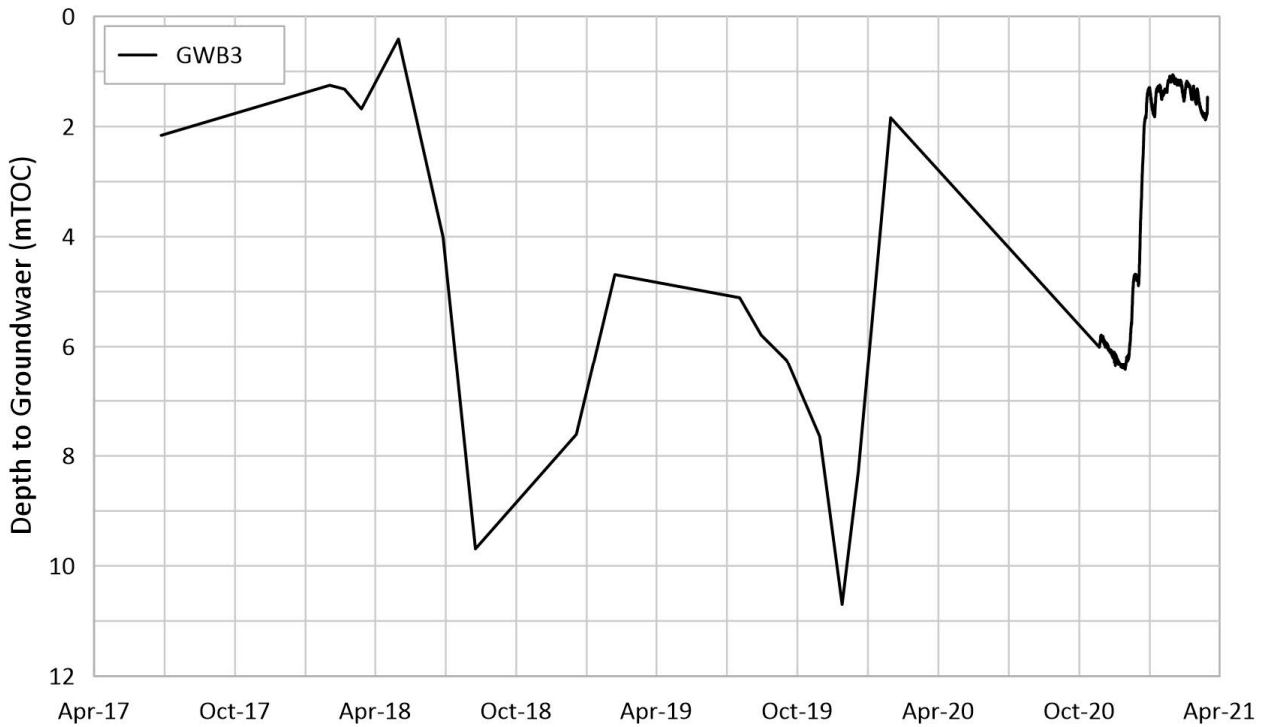


Figure 2-8 Hydrograph for GWB3 constructed in the Burrell Creek Formation at Grants deposit

Groundwater levels in the shallow bores constructed in the heavily weathered top of the BCF or alluvial sediments ranged from 4.4 – 6.6 mBGL in the late dry season (Figure 2-9). They rose steadily in response to wet season rainfall from December 2020 and plateaued by mid-February at levels around the natural surface. Alluvial sediments screened by BPG2s were dry in the late dry season and only became saturated in late December, 2020. The seasonal water level fluctuation in the shallow bores ranged from 3.1 – 5.5 m.

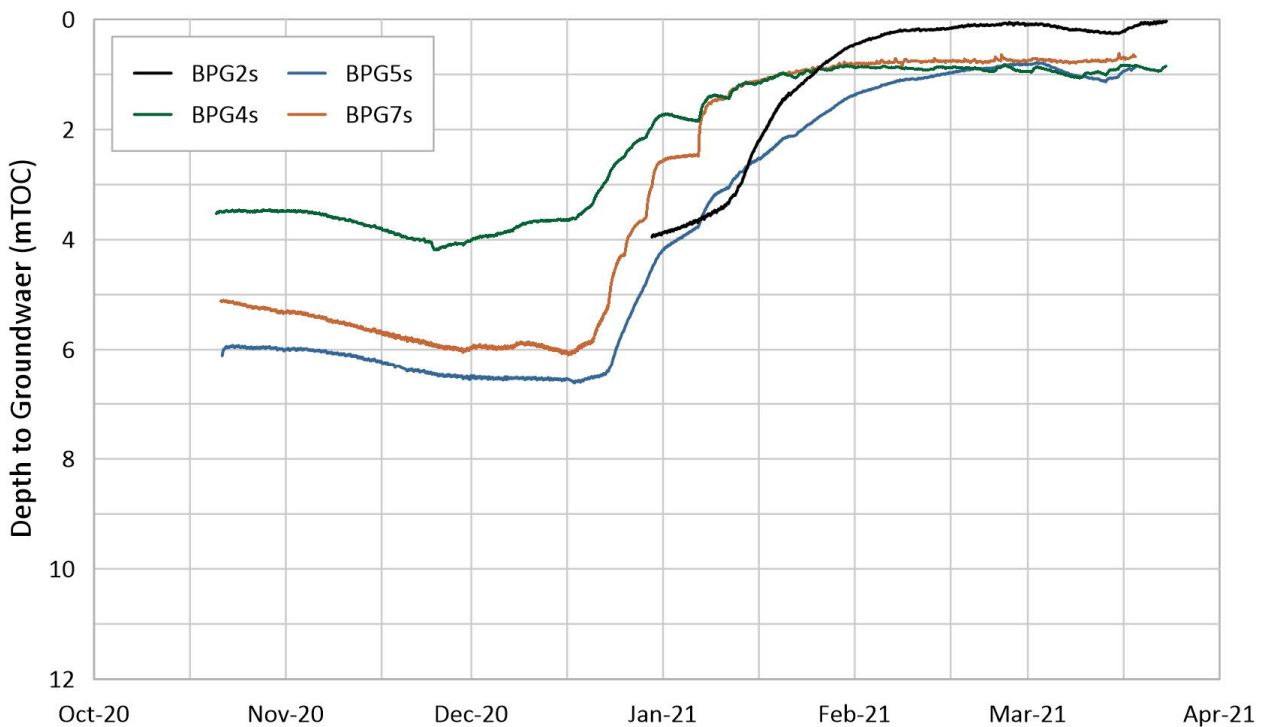


Figure 2-9 Hydrographs for BP33 Shallow Bores (depths 3.5 – 8 m)

2.5.6. Groundwater Flow Direction

The groundwater monitoring bores at BP33 were surveyed to a common height datum mAHD (metres Australian Height Datum). Survey levels were used with the water level monitoring data to generate two potentiometric surfaces: an end of dry season 2020 surface (Figure 2-10) and a wet season 2021 surface (Figure 2-11). These surfaces reflect the groundwater elevation in the deeper monitoring bores. However, as vertical gradients between the shallow and deep bores are predominantly less than 1 m (see Section 2.5.7) the groundwater flow pattern is also representative for shallow bores constructed in the top of the BCF.

Figure 2-10 shows that the local flow direction is south-east across the BP33 site with groundwater moving from the more elevated areas in the north-west of the site to the lower lying areas along the drainage line in the south-east. The flow direction does not change between the dry and wet season surfaces, however the groundwater gradients become much steeper in the north-east of the site in the wet season (Figure 2-11). This is attributed preferential recharge occurring on the higher elevations. Water levels in the BP33 pit-lake are slightly elevated relative to the surrounding watertable surface suggesting that the pit-lake is operating as a local recharge feature.

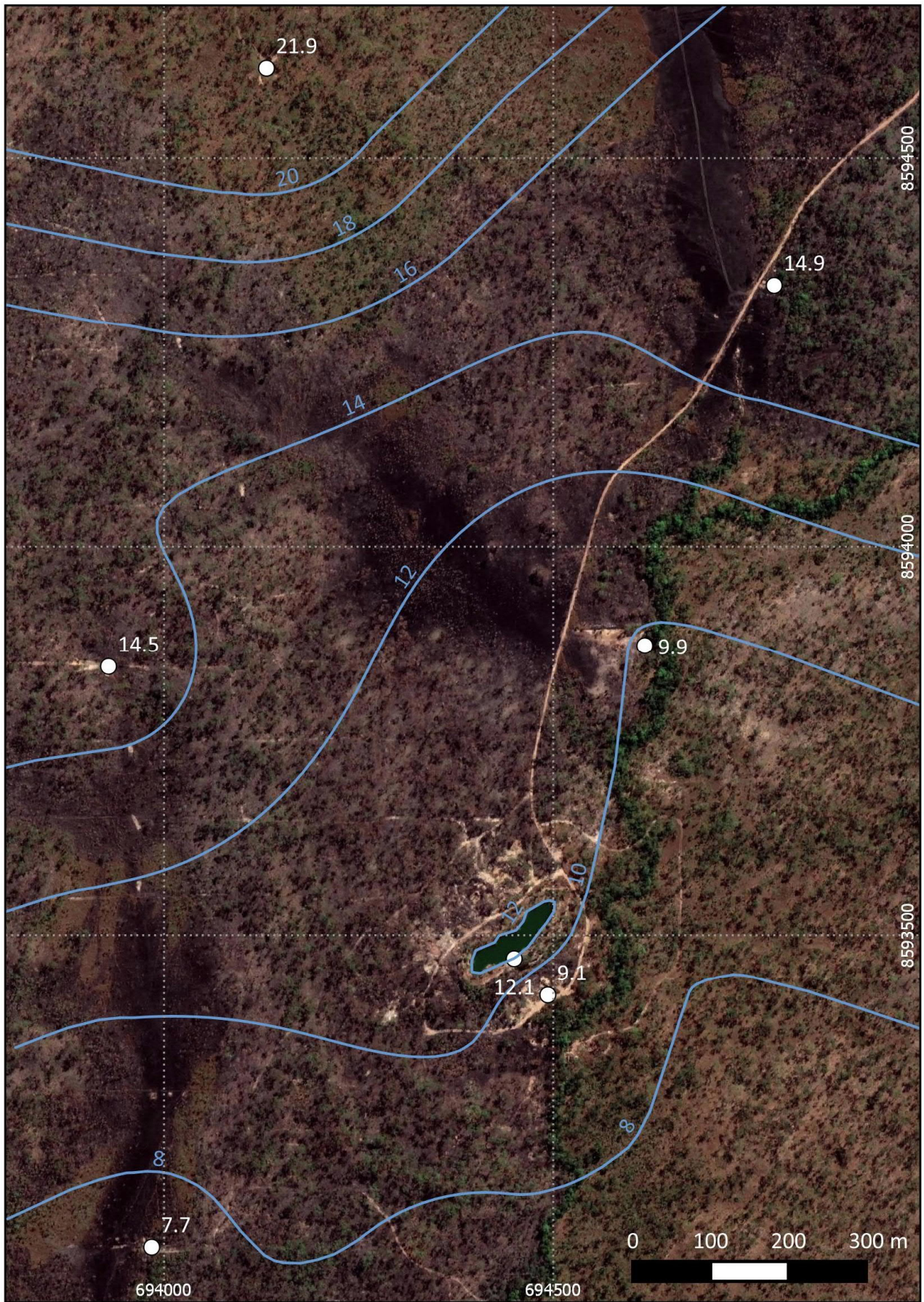


Figure 2-10 Late dry season (December 2020) potentiometric surface for the BCF aquifer



Figure 2-11 Wet season (February 2021) potentiometric surface for the BCF aquifer

2.5.7. Vertical groundwater gradients

There are five nested monitoring sites across the BP33 monitoring network. Deeper bores screen fracture zones in the BCF while shallow bores are variously constructed in the alluvial sediments or in the weathered top of the BCF. In most instances upward vertical gradients suggest groundwater discharge zones while downward gradients are consistent with recharge zones. With the exception of BPG4 vertical gradients at all sites up upwards (Table 2-3). The absence of downward gradients at sites around the drainage lines suggests that infiltration from seasonal surface water flows is not a dominant recharge process to the BCF. Rather, groundwater appears to be recharging preferentially on the slightly elevated areas to the north and west of the BP33 site and moving laterally to the lower lying areas around the drainage lines. This mechanism is supported by the seasonal change in gradients with the upward gradient increasing in magnitude during the wet season. The exception is monitoring site BPG4, which is located adjacent to the existing BP33 pit-lake. Vertical gradients at this site are downward, which suggests that the pit-lake is acting as a local recharge source to the surrounding BCF aquifer.

Table 2-3 Dry season and wet season vertical groundwater gradients across the BP33 site.

BORE ID	SCREENED INTERVAL (mBGL)*	FORMATION SCREENED	DRY SEASON RWL (mAHD)	GRADIENT (m)	WET SEASON RWL (mAHD)	GRADIENT (m)
BPG2i	22.3 – 28.3	Burrell Creek Deep	14.89	-	19.49	+ 0.51
BPG2s	2.5 – 3.5	Alluvial	Dry	-	18.98	+ 2.43
BPG3i	41.8 – 48.8	Burrell Creek Deep	9.88	-	12.82	+ 2.43
BPG3s	3.5 – 4.5	Alluvial	Dry	-	10.39	+ 2.43
BPG4d	47 – 109	Burrell Creek Deep	9.07	- 0.92	12.53	- 0.13
BPG4s	5 – 8	Burrell Creek Shallow	9.99	- 0.92	12.66	- 0.13
BPG5i	49.3 -55.3	Burrell Creek Deep	6.25	+ 0.6	12.47	+ 1.03
BPG5s	5 – 8	Burrell Creek Shallow	5.66	+ 0.6	11.44	+ 1.03
BPG7i	46.2 – 52.2	Burrell Creek Deep	7.65	+ 0.21	13.65	+ 0.98
BPG7s	4 - 7	Burrell Creek Shallow	7.44	+ 0.21	12.67	+ 0.98

2.5.8. Groundwater quality

Groundwater sampling has been undertaken on a monthly basis on the BP33 monitoring bores with six sampling rounds completed since the bores were constructed in September 2020. Groundwater samples have been analysed for major ions, dissolved and total metals, and nutrients.

The groundwater quality in the deep monitoring bores (screening slightly weathered to fresh BCF) is slightly acidic to neutral (pH 4.4 – 7) and fresh with an EC range of 60 – 330 $\mu\text{S}/\text{cm}$. The wet season samples are marginally fresher (25 $\mu\text{S}/\text{cm}$) than those collected at the end of the dry season, which likely reflects the influx of lower conductivity rainfall from wet season recharge. Spatially, groundwater from the two northern monitoring bores BPG1 and BPG2i has a lower EC (average 60 – 70 $\mu\text{S}/\text{cm}$) than the central and southern sites (average 200 – 310 $\mu\text{S}/\text{cm}$). Groundwater quality in the five shallow bores constructed in the weathered top

of the BCF and the alluvial deposits is fresh (EC 20 – 130 $\mu\text{S}/\text{cm}$) and mildly acidic (4.7 – 6.8 pH).

The groundwater quality samples have been compared against the ANZECC 2000 water quality guideline for 95% freshwater ecosystem protection. All bores periodically exceed guideline values for aluminium, zinc and copper. The deep BCF bores, with the exception of the northern sites BPG1 and BPG2i, have elevated concentrations of arsenic (0.017 - 0.34 mg/L) and exceed the guideline value. Groundwater from shallow BCF bore BPG4s, located adjacent to the pit-lake, exceeds guideline values for arsenic, lead and nickel. All other dissolved metal and nutrient concentrations are below guideline values.

2.6. Existing Groundwater Users

Existing bores and groundwater users within 10 km of the BP33 site were identified using NRMmaps (DEPWS, 2021), results are summarised in Table 2-4.

Excluding monitoring bores drilled for the lithium project there are six registered groundwater bores within 10 km of the BP33 site. The closest groundwater bore is RN023177, located 2.5 km north of BP33. RN023177 was drilled in 1984 and was constructed in the BCF as a potential water supply bore for Greenex mining operations at Observation Hill Dam. The bore is not currently in use. The next closest groundwater bore RN041993 is located 4.6 km south of BP33 on the Fog Bay Road. RN041993 was drilled in 2020 to provide a domestic water supply.

Table 2-4 Registered bores within 10 km of the BP33 project

BORE ID	Easting GDA94 Z52	Northing GDA94 Z52	Distance from BP33 Project (km)	Use	Comment
RN023177	695330	8595810	2.5	None	Abandoned Greenex mine bore
RN041993	694502	8588795	4.6	Production	Domestic supply
RN038217	688884	8586501	8.9	Production	Domestic supply
RN036421	688271	8586122	9.6	Production	Domestic Supply
RN024254	687130	8586960	9.8	Production	Dog Mine Bore
RN030887	703516	8589291	9.9	Production	Agriculture and domestic

2.7. Environmental Receptors

2.7.1. Groundwater Dependant Ecosystems Atlas

Groundwater dependent ecosystems (GDEs) have been identified using the GDE Atlas, a national dataset of Australian GDEs developed by the Bureau of Meteorology (BOM, 2021) to assist groundwater management and planning. Figure 2-12 maps the terrestrial ecosystem layer in the vicinity of BP33. This layer shows the potential for ecosystems that rely on the subsurface presence of groundwater – including vegetation ecosystems such as forests and riparian vegetation. Four mapped categories are presented: known GDEs based on regional studies and high, medium and low GDE potential based on remote sensing and image analysis.

The GDE Atlas maps an area of medium GDE potential (shown in green in Figure 2-12) along the drainage lines to the immediate east and south of BP33.

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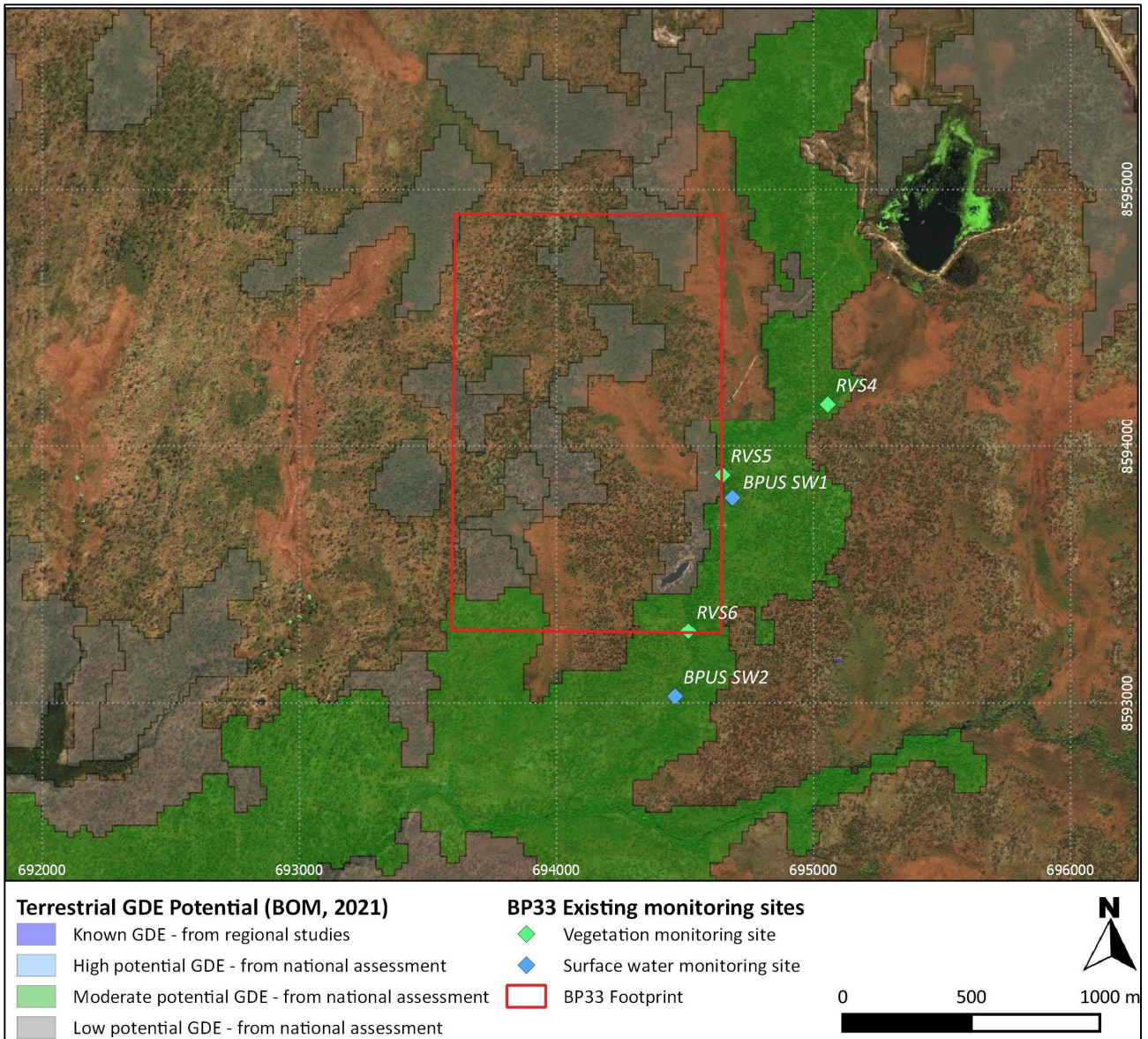


Figure 2-12 GDE classes within and surrounding the BP33 project area.

2.7.2. Field Surveys

EcOz Environmental Consultants (EcOz) was engaged by Core Lithium to map riparian vegetation communities and collect baseline information on community structure and condition along the drainage line downstream of OHD. The field survey (EcOz, 2019) mapped 3.6 hectares of GDE vegetation within the riparian zone of the drainage line. Three vegetation monitoring sites were established (see Figure 2-12 for locations) as part of the survey. At the time of surveying in June 2019, pools of water were observed around the northern two monitoring sites, RVS4 and RVS5.

As part of the Environmental Impact Assessment (EIS) for the Grants Lithium mine EcOz established two surface water monitoring sites on the drainage line south of OHD: BPUS SW1 and SW2 (Figure 2-12). The sites have been monitored at a quarterly frequency since October 2017. Surface water flows at the monitoring sites generally cease early in the dry season (April/May). Anecdotal information suggests that in wetter years pools of surface water persist throughout the dry season.

2.8. Mining activities

The proposed mine at BP33 comprises three components that will interact with the groundwater system:

- Box-cut;
- Decline and
- Stopes

The relationship between the mine components is presented below in Figure 2-13.

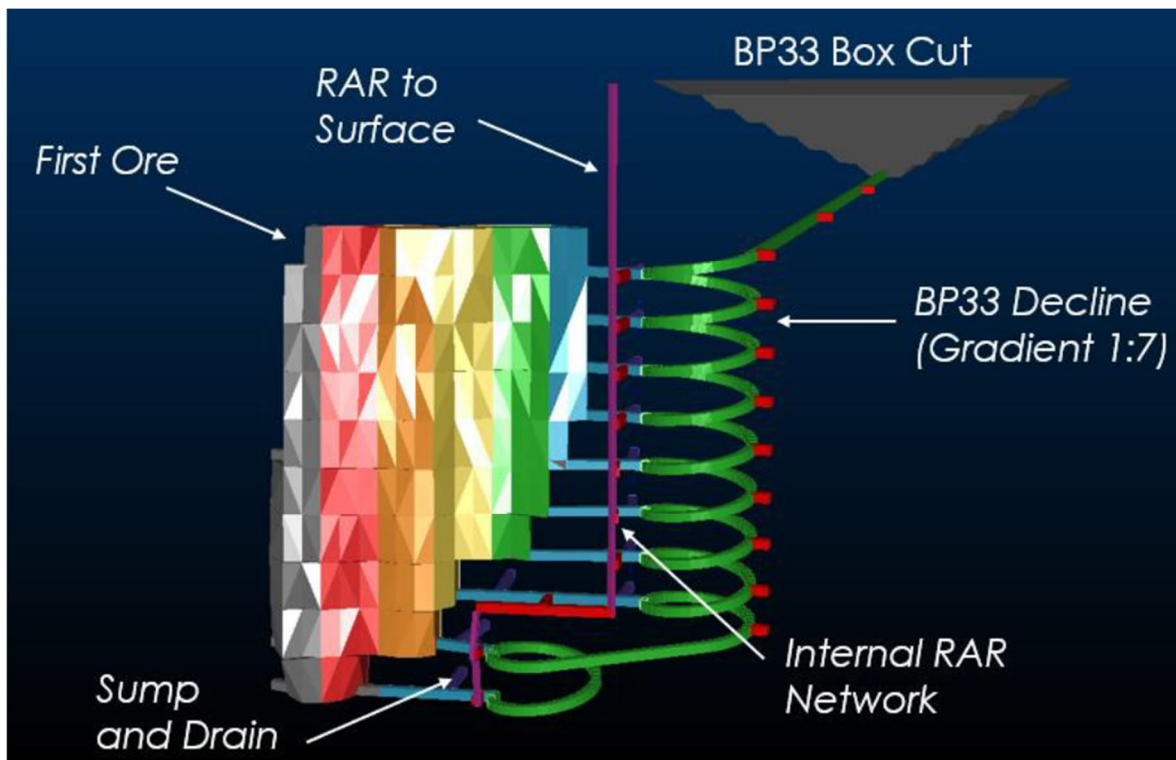


Figure 2-13 Relationship between the BP33 underground design for life of mine.

2.8.1. Box-cut description

To provide geotechnical stable conditions for development of the underground portal, a box-cut will be excavated. The box-cut will cover an area of six hectares and will be excavated to at least 10 m below the oxidised waste rock, a depth of 60-70 m.

A 2 metre high safety bund with a base width of 7.3 m will surround the box-cut excavation. The bund is a safety measure and will prevent surface water run-off entering the box-cut excavation. On the western side of the box-cut, a contour drain will capture surface water run-off from the adjacent elevated areas to reduce the risk of water build up behind the safety bund. A sump and pump system in the base of the box-cut will be used for dewatering of rainfall and groundwater inflows.

2.8.2. Underground mine description

A portal installed near the base of the box-cut and a 400m decline will be used access the top of the ore body. A further 1.7 km of decline constructed over the life of mine will provide access to each production level, down to an elevation of approximately -360 mAHD.

Available Data

The underground mine will comprise 10 production levels (five stope horizons). Each level will contain stope access from the decline, sump/drainage, ventilation network and a turning/stockpile bay. The underground mine will be ventilated via a dedicated raise bored Return Air Raise (RAR) to the surface.

2.8.3. BP33 mining schedule and underground development

The BP33 underground workings are represented using time varying seepage face boundary conditions. The schedule has been simplified by assuming that development occurs based on the excavation of the box-cut and five underground stope horizons (refer to Figure 2-14).

Table 2-5 Underground mine development schedule used in the groundwater model.

Component	Interval	Period (Months)
Box-cut	20 to -40	17 to 20
UG stope horizon 1	-90 to -150	31 to 36
UG stope horizon 2	-150 to -210	37 to 42
UG stope horizon 3	-210 to -270	43 to 48
UG stope horizon 4	-270 to -330	49 to 54
UG stope horizon 5	-330 to -360	54 to 59

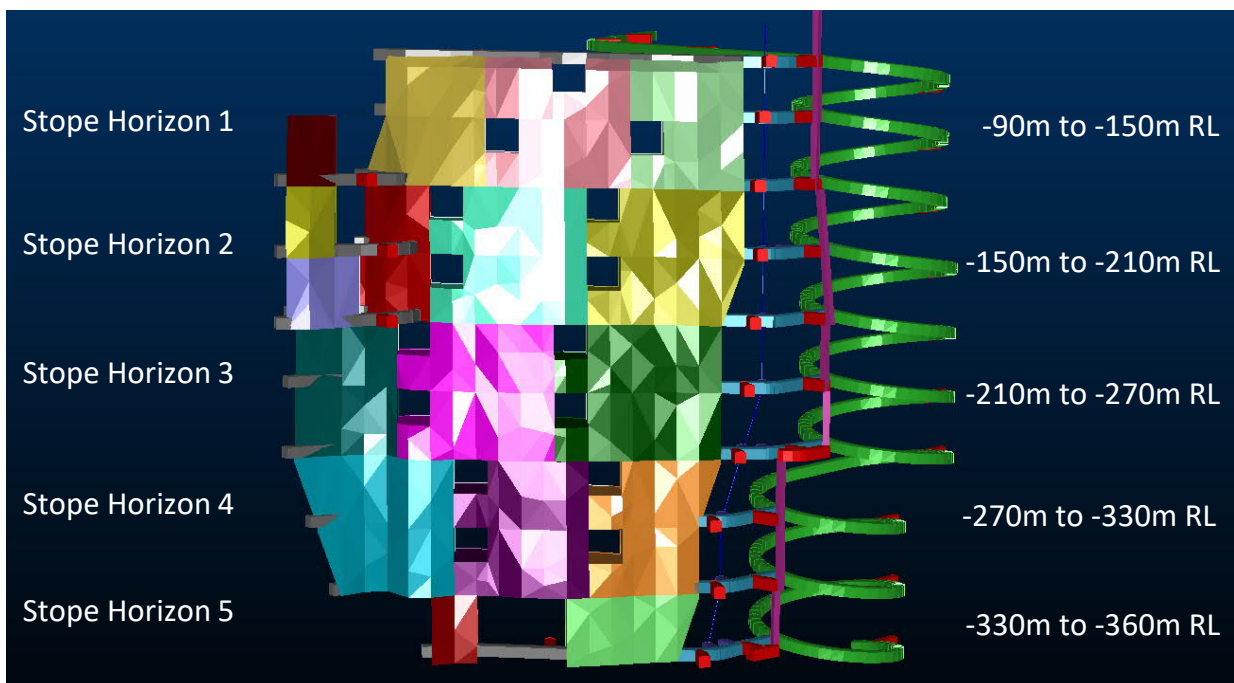


Figure 2-14 BP33 underground stope horizons.

2.8.4. Mining and underground development schedule

Mining at BP33 is expected to take 48 months and commence at or near the end of mining at the GLP. The timing of the various components considered in the modelling is presented in Figure 2-15.

Month	1 - 12	13 - 24	25 - 36	37 - 48	49 - 60
Grants pit	1 - 31				
BP33 Box-cut		17 - 20			
BP33 decline			24 - 51		
BP33 mining			31 - 59		

Figure 2-15 Mining plan used to schedule the various components in the groundwater model.

2.8.5. BP33 box-cut and underground mine closure

On the completion of underground mining activities at BP33 the mine workings will be rehabilitated in the following fashion:

- The stopes will be left largely as voids with a small proportion of backfill (estimated at between 5 - 6% of the void volume). The backfill material will comprise of fresh waste rock reclaimed from the BP33 underground mining process. It is assumed that the infill material will have a higher storage coefficient of 10% relative to the undisturbed host rock storage coefficient of 1%.
- The decline will be left as 100% open void.
- The portal at the base of the box-cut will be plugged with concrete.
- The mine shafts will be partially plugged with concrete with remaining void filled with backfill material. It is assumed the backfill will have the same material properties as the waste rock used in the stopes.
- The box-cut will be backfilled with oxide mine waste from BP33. This is effectively the same material that will be removed during the excavation of the box-cut. The oxide waste will be stored onsite in a waste rock dump and subsequently used to re-fill the box-cut void at the end of mining. It is assumed that the infill material will have a higher storage coefficient of 10% relative to the undisturbed weathered Burrell Creek Formation, which has a modelled specific yield of 1.5%.

3 Conceptual model

3.1. Introduction

The development of a conceptual model is one of the most important steps in groundwater modelling (Barnett et al, 2012). The conceptual model establishes the basic design principles for a groundwater model and identifies any key knowledge gaps to guide future investigations.

At this stage of the modelling process, a decision is made on what processes to include (or exclude) and what simplifying assumptions should be made to achieve the modelling objective(s). These decisions will strongly influence the mathematical model and ultimately the modelling outcome.

3.2. Groundwater system extents

Similar geological / hydrogeological conditions (Burrell Creek Formation) extend well beyond the expected impact of the Finnis Lithium Project, therefore in order to build a functional numerical groundwater model, the modelled groundwater system extents have been taken from hydrological features such as surface water catchment divides and surface water drainage features.

The extents of the groundwater model are presented below in Figure 3-1. The model domain has adequate lateral extents to prevent the interaction between areas showing potential changes to the groundwater system due to mining activities and the model boundaries (approximately 3 – 4 km separation).

The geometry and layering of the groundwater model are based on the following criteria:

- The western and eastern boundaries roughly correspond with surface water drainage divides, assuming that the groundwater surface is a subdued reflection of the topography, then these will correspond to groundwater divides.
- The western boundary also corresponds with a geological contact between the BCF to the east and the Welltree Metamorphics to the west.
- The northern boundary coincides with drainage features, which are assumed to be tidal and forms a constant head.
- The southern boundary coincides roughly with surface water drainage divides and is likely to form a local no-flow boundary.

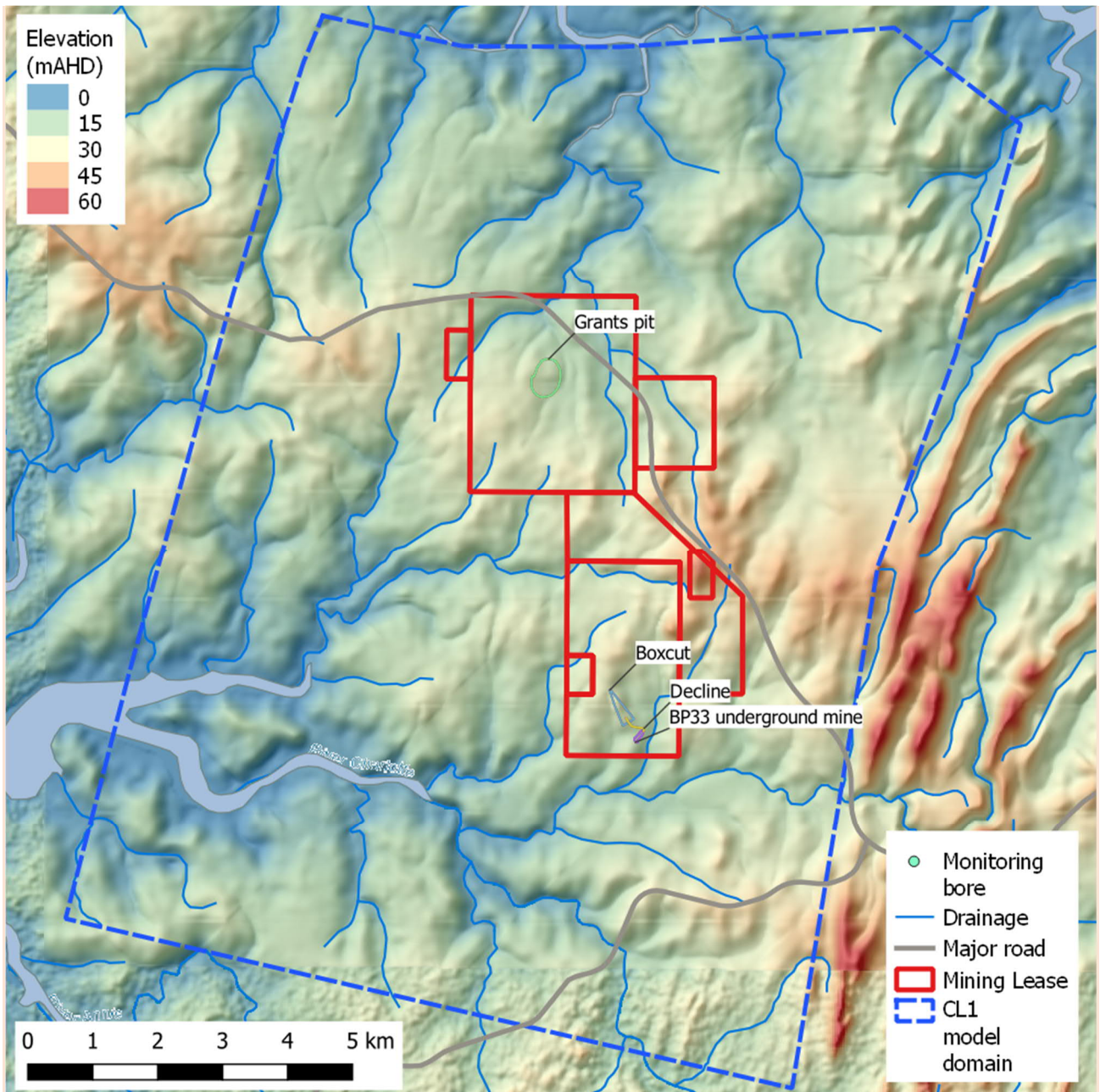


Figure 3-1 Core Lithium groundwater model domain.

3.3. Hydraulic characteristics

The BCF comprises heavily weathered shale, siltstone and strongly foliated phyllite with lenses of quartz pebble conglomerate. Investigation bores at BP33 intersected a thin cover of Quaternary sediments overlying the BCF. These sediments range in thickness from 2 – 4.5 m and comprise of silty sands with minor laterite horizons. With the exception of one site (BPG2s) the Quaternary sediments were unsaturated during the late dry season.

Low yielding localised fractured and weathered aquifers are present in the BCF typically occurring at the base of the weathered zone. Discrete aquifers also occur where drilling intersects fracture zones within the fresh BCF. The most permeable sediments occur in the Cenozoic sands and gravels, and the laterised top of the Burrell Creek Formation. However, the potential of these deposits to store and transmit groundwater is not significant due to their

limited saturated thickness. The permeability of the BCF is relatively low with hydraulic testing indicating hydraulic conductivity values of around 0.03 m/d for unfractured BCF and 1 m/day for fractured BCF. The storage characteristics are unknown, however, the specific yield is expected to be low and in the order of 0.01. In the absence of site data the specific yield is based on typical values for weathered and fractured rocks and is consistent with values adopted for other groundwater modelling studies undertaken in similar hydrogeological environments (i.e. the Burrell Creek Formation).

3.4. Groundwater flow dynamics

Groundwater flows in a south-easterly direction across the BP33 site, moving from more elevated terrain in the north-west of the site to lower lying areas along the drainage line in the south-east. The groundwater flow direction does not vary significantly between the wet season and dry season, however, groundwater gradients steepen in the north-west during the wet season suggesting that preferential recharge occurs in the elevated areas. Groundwater levels in the lower lying areas rise rapidly in response to wet season recharge before plateauing as they approach ground level. The groundwater level response suggests that BCF aquifer effectively fills up to capacity in the lower lying areas during the wet season. Vertical gradients suggest that the lateral movement of groundwater from elevated areas, rather than direct recharge from rainfall or surface water, drives the water level response in the lower lying areas.

Regionally, there is limited groundwater level and elevation data. However, the watertable around the study area is likely to broadly mirror the topography. A catchment divide occurs in the north of the site, which separates the BP33 site from mine activities at the GLP 4.5 km to the north-west. A groundwater divide is inferred along the catchment divide with groundwater around BP33 moving generally in a southerly direction toward Bynoe Harbour.

3.5. Recharge

Two mechanisms provide recharge to the aquifers of the study area:

- Direct (or diffuse) recharge – this is defined as the water added to the groundwater in excess of soil moisture deficits and evapotranspiration, by direct vertical percolation of precipitation through the unsaturated zone and is typically distributed over large areas; and
- Indirect (or local) recharge – this results from the percolation of water to the water table following runoff as ponding in low-lying areas or through the beds of surface water courses and features (e.g. BP33 pit-lake) (Lerner et al., 1990).

Groundwater level monitoring data suggests that direct recharge is likely to be the dominant mechanism across the BP33 site.

Estimates of recharge rates are based on the watertable fluctuation method (WFM) (Healy, 2010). Based on the water level monitoring data an annual water level variation of 9 m is assumed for bores in the elevated areas (BPG1 and BPG6). For the bores in the lower lying areas the annual variation in groundwater level is assumed to be between 3 – 6 m. A specific yield range of 0.01 – 0.02 is adopted in the recharge estimate. The WFM approach estimates recharge rates at between 30 – 120 mm/year for the lower lying areas and 90 – 180 mm/year for the more elevated areas.

3.6. Groundwater Discharge

Natural mechanisms for groundwater leaving the aquifers in the study area are thought to be via:

- Evapotranspiration and diffuse discharge where groundwater is relatively close to the surface (including from the surface of the BP33 pit-lake);
- Discharge to streams and creeks; and
- Throughflow to the south;

Evapotranspiration can be estimated from studies conducted in similar vegetation types and climatic conditions. Cook et al (1998) provided an annual estimate of evapotranspiration from the unsaturated zone of 1110 mm for an annual rainfall of 1720 mm. The volume and rate of groundwater discharge to surface features (streams and creeks) is expected to be relatively small as the aquifer has a low hydraulic conductivity.

3.7. Water budget

3.7.1. Catchment water budget

The saturated water balance should satisfy the following flux equation:

$$REg - \Delta Ly - \Delta D - EVT - A = \Delta S$$

Where:

- REg = gross recharge to the saturated zone
- ΔLy = net horizontal flow of groundwater across the model boundaries
- ΔD = net drainage from groundwater to surface water
- EVT = evapotranspiration from the groundwater
- A = groundwater abstraction
- ΔS = change in groundwater storage

That is the sum of the fluxes is equal to the change in groundwater storage in the aquifer. All fluxes vary in space and time. Some values can be measured directly, for example, the discharge from extraction wells, whereas other values have to be indirectly evaluated by appropriate methods or models.

The absolute value of these fluxes is likely to contain error due to spatial lumping, parameter estimation and various assumptions used in the calculations. However, the input parameters such as aquifer geometry, transmissivity and specific yield are considered to be reasonable and the underflow and storage values determined are also reasonable. However, due to the nature of the recharge processes analytical estimates are likely to be accurate to only an order of magnitude and are expressed as long-term averages.

3.8. Summary hydrogeological conceptualisation

Groundwater flow around the BP33 site occurs in a fractured and weathered aquifer within the BCF. The pegmatite, which hosts the lithium resource, has limited spatial extent and negligible primary porosity. It is expected to operate as a fractured rock aquifer with similar or lower permeability than the surrounding host rock (BCF). Alluvial deposits occur around drainage lines and from in-situ weathering of the BCF but are thin (< 4.5 m), discontinuous and typically only saturated during the wet season.

The weathering profile in the BCF is significant to the groundwater dynamics. Based on examination of numerous boring logs, the top 3 m of material is generally completely weathered, very highly fractured, or unconsolidated. The weathering profile generally extends from 30 to 60 m below land surface. Weathering is often associated with increased fracturing, infilling of fractures with clay or mineralisation, or oxidation. The degree of weathering decreases with depth. The alluvium and uppermost weathered portion of bedrock have the potential to transmit reasonable volumes of groundwater, especially during rain events. However, they are generally unsaturated except in the immediate vicinity of the local streams and surface water bodies. Also, the infilling and mineralisation along fractures in the weathered zone above 30 m depth has the potential to cause a decrease in their transmissivity.

Groundwater flow in the BCF aquifer is away from slightly elevated areas in the north-west and toward lower lying areas along the drainage line in the east and south of the site. The regional groundwater gradient is toward the south and the groundwater flow direction generally mimics the topography. A groundwater flow divide is inferred along the topographic divide located in the north of the BP33 site.

Streams in the area are inferred to act as the discharge points. Topographic highs and surface water ponds, including the existing BP33 pit-lake and proposed dams/water storages, act as recharge areas. Groundwater recharging in the vicinity of the BP33 mine and its infrastructure is expected to migrate offsite, either as discharge to surface water features or through evapotranspiration losses.

Table 3-1 Summary of key features of the hydrogeological conceptualisation

ASPECT FEATURE(S)	DESCRIPTION
Hydrostratigraphy	Groundwater is present in the weathered and fractured Burrell Creek Formation. The thin veneer of alluvial sediments is predominantly unsaturated across the site with groundwater only present during the wet season.
Flow dynamics	Groundwater generally flows from north to south and locally from areas of higher topography to areas of lower topography such as drainage features.
Recharge processes	Recharge primarily occurs as diffuse recharge. This hypothesis implies that preferential recharge is not significant.
	Total recharge fluxes were estimated at 16.7 GL/year, which (for an assumed total recharge area of 167.5 km ²), equate to rates of approximately 100 mm per year, or 2.7×10 ⁻⁴ m/d.
Discharge processes	Diffuse discharge also occurs via streambed seepage (unquantified) and via evapotranspiration from shallow groundwater. The fluxes were estimated at 4 GL/year respectively.
	Total discharge fluxes were estimated to range from 17 to 18 GL/year, which (for an assumed total discharge area of 167.5 km ²), equate to rates of approximately 90 – 104 mm per year, or 4×10 ⁻⁴ to 7×10 ⁻⁴ m/d.

4 Groundwater flow model design

4.1. Introduction

4.2. Model platform

The FEFLOW (Finite Element subsurface FLOW and transport system v 7.3.6) modelling code was developed by DHI-WASY GmbH (Diersch, 2015). This code is an industry standard groundwater modelling tool to study groundwater level behaviour within groundwater systems.

FEFLOW handles a broad variety of physical processes for subsurface flow and transport modelling, and simulates groundwater level behaviour indirectly by means of a governing equation that represents Darcy groundwater flow processes.

FEFLOW provides the capability to explicitly model recharge processes and surface water/groundwater interactions. Rejected recharge is an important mechanism in Top End groundwater systems and adequately characterising this process is critical if the model is to accurately assess the impacts from the mining development. The ability of FEFLOW to explicitly model rejected recharge and surface water/groundwater interactions are major reasons for its selection as the preferred modelling code for the BP33 groundwater model.

4.3. Model domain and grid

4.3.1. Model domain

The 3D finite difference model domain is roughly centred on the Core mining activities and covers an area of 167.5 km² which is about two and a half times the area of the GLP model (77.2 km²). The mesh has been refined within the footprint of GLP pit and the BP33 box-cut and underground workings. The model domain is discretised into a mesh consisting of 12089 elements per layer.

The final FEFLOW mesh extents are summarised in Table 4-1 and the model domain is presented below in Figure 4-1.

Table 4-1 Core Lithium project numerical flow model domain specifications.

X min	685624
X max	700337
Y min	8588042
Y max	8604892
Model area	167.5 km ²
Map projection	GDA94 / MGA zone 52

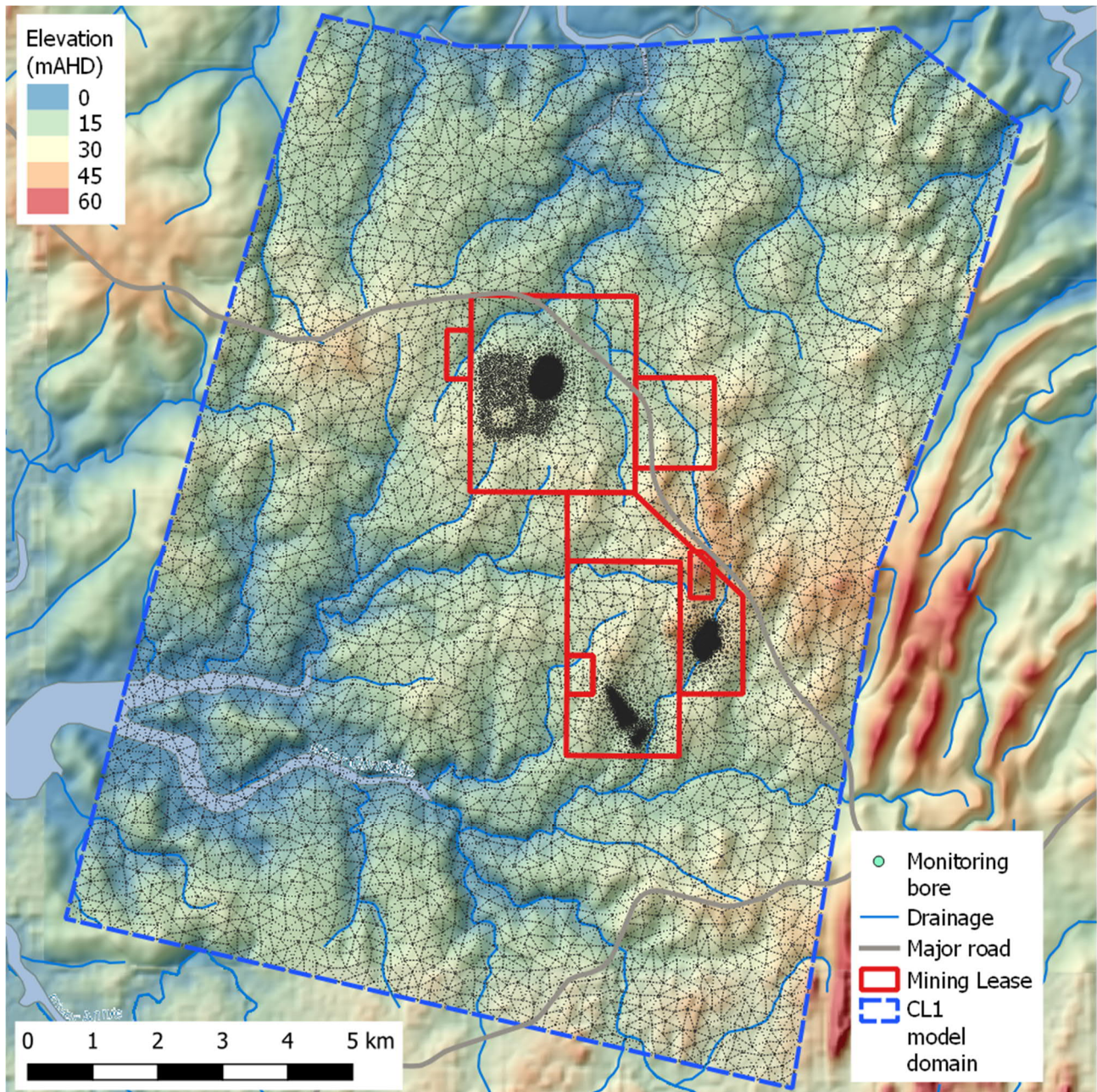


Figure 4-1 Core Lithium Project FEFLOW groundwater model domain and grid.

4.3.2. Boundary conditions

The boundary conditions (BCs) are defined at nodes along the boundary or within the model domain. There are four main boundary conditions available in FEFLOW.

- Head BCs – this type of BC prescribes a head at the boundary node. The head can be fixed at a prescribed value or assigned to a time series file.
- Flux BCs - this type of BC describes a constant or time varying flux across the outer boundary of the model. A time varying flux can be specified as a mean step-accumulated discharge (e.g. m³/d). A positive value implies an inflow to the model cells.

- Well BCs - this type of BC is applied to nodes and represent a time-constant or time-varying local injection or abstraction of water at a single node or at a group of nodes. No well BCs are currently employed in the CL1 model.
- Zero flux BCs - This is a flux BC that specifies no-flow, which is the default at the edges of the model domain.
- Seepage face BCs - A seepage face is a specified head BC with a zero-flux inflow constraint applied. This means the BC can discharge groundwater from the model domain, but no inflow to the model domain can occur.

The locations of the boundary conditions at the extents of the model domain are depicted above in Figure 4-1.

4.3.3. Areal flux distributions (recharge and ET)

The recharge is applied to the model as a Parameter Expression using the In / outflow on top / bottom areal flux distribution.

The Parameter Expression is a user-defined expression linking the time-varying values of recharge to the In / outflow on top / bottom parameter, based on the dependencies of other parameters, in this case the recharge reference distribution, maximum evapotranspiration flux, extinction depth and reference distribution. Scaling factors are applied to the time-varying rainfall values using the recharge zones and the distribution of ET based on the vegetation mapping.

The ET function is determined using an estimate of the potential evaporation rate, an estimate of root depth or depth of capillary rise where vegetation is absent and the extent of persistent vegetation.

The ground surface along the drainage features is represented by seepage face boundary conditions.

4.3.4. Representation of the pit during mining

Dewatering of the GLP pit during excavation is simulated using seepage face boundary conditions that are activated sequentially in time. A seepage face is a specified hydraulic-head boundary condition with a zero-flux inflow constraint applied. This means the boundary condition can discharge groundwater from the model domain, but no inflow to the model domain can occur. The implication of using seepage face boundary conditions to represent the pit is that the inflow to the pit is a predicted output of the modelling.

The seepage face requires a reference elevation, which in this case has been determined from the planned progression of the pit-levels over the life of mine (CloudGMS, 2018).

4.3.5. Post closure pit-lake representation

The development of the pit-lake post mine closure is represented by the lfmLake module developed by DHI.

lfmLake is an IFM plug-in which allows the incorporation of lakes within a FEFLOW model. The plug-in calculates the development of water levels from internal fluxes (received or discharged by the lake from the groundwater model) and/or external fluxes (such as rainfall and evaporation defined by the user). The plug-in dynamically adjusts the horizontal extent of the lake depending on water level and surface elevation.

IfmLake uses the pit-lake bathymetry (“IfmDTM”), the external net inflow into the lake (“InflowExtMM” such as evaporation and rainfall) and a function describing the water level vs the lake volume $f(\text{Volume})$.

If the water level in the lake is higher than the surface level at a node, a third kind boundary condition is set at this node with a value identical to the lake water level (in mAHD). Additionally, a head boundary constraint is set with a value identical to the nodal value of the reference distribution “IfmDTM”. This constraint limits the value ($h_{ref} - h_{gw}$) to the actual water depth at the node ($h_{ref} - \text{dtm}$). This is useful if the groundwater level drops below the base of the lake.

InflowExtMM represents an external net inflow into the pit-lake (such as evaporation and rainfall). This rate is given in mm/d and the area of the lakes is taken into account during the simulation (in principle the area of the lake is determined at the beginning of each time step).

The level of the lake is calculated using an empirical function $f(\text{Volume})$ relating lake water level to pit-lake storage volume. The Volume stored in the pit-lake at the end of the time step is calculated by $\text{Volume}_{end} = \text{Volume}_{begin} + (\text{Inflow}_{GW} + \text{Inflow}_{ExtMM}) \cdot dT$.

4.3.6. Vertical discretisation / model layers

A total of three model layers were used to represent the groundwater flow system. The layers coincide with the upper completely weathered / laterised horizon, the moderately / highly weathered zone to 30-40 metres below ground levels and the slightly weathered / fresh rocks.

The fresh basement rocks are discretised using slices corresponding to the underground stope horizons (-90m, -150m, -210m, -270m, -330m and -360m) presented previously in Figure 2-14.

4.4. Transient model design & construction

4.4.1. Simulation period and time stepping

The period from 01/01/2010 to 01/06/2021 (40179 – 44348d) was selected as the period for parameter estimation. This period was selected because it provides a reasonable ‘warm-up’ period prior to the period of available groundwater levels. The FEFLOW simulation time, equation solver and numerical settings are presented in Table 4-2.

Table 4-2 FEFLOW simulation specification settings

Model code	FEFLOW
Software version	7.3.6 (x64)
Mesh	
Element geometry	Triangle prism
Free surface	3D phreatic surface (fixed mesh)
Head limits for unconfined conditions	
Top of model domain	Unconstrained head
Storage change in phreatic top layer	Extend storage of unconfined layer to water table
Bottom of model domain	Unconstrained head
Numerical parameters	
Time stepping	Adams-Bashforth/Trapezoid rule (AB/TR) predictor-corrector
Error tolerance	
Euclidian L2 integral (RMS) norm	5e-03
Maximum number of iterations per timestep	12
Equation System Solver	Preconditioned conjugate-gradient method

4.4.2. Error tolerance

The Error tolerance (units: 10^{-3}) is defined as the averaged absolute error (change in the primary variable) divided by the maximum value occurring in initial or boundary conditions. For the averaging process over all nodes, the default Euclidian L2 integral (RMS) norm was used and set to a value of 5.

4.4.3. Transient model initial heads

Initial heads for the transient model were obtained by running the model for a 11.5 year warm-up period starting 01/01/2010 and ending 1/6/2021.

5 Parameter estimation

5.1. Parameter Estimation Approach & Criteria

Calibration or parameter estimation is the process, subsequent to model design and construction, of determining a set of parameters, boundary conditions and stresses that produce simulated heads and fluxes in order to match field-measured values within a pre-established range of error, so that the model can be accepted as a good representation of the physical system of interest. Finding this set of values from a set of observed heads amounts to solving the inverse problem.

During the calibration process, important model parameters are adjusted, within realistic limits, to produce the best match between simulated and observed data. The process begins with an initial estimation of parameters (hydraulic conductivity horizontal and vertical, specific yield, recharge, boundary conditions, etc.) for each active element in the model mesh. Adjustment of parameters can be done manually through trial and error or automatically.

Regardless of the technique employed all parameter optimisation methods require:

- selection of a number of parameters to be estimated;
- an objective function, that is, a function of the measured values, defined such that its value is to be minimised; and

- constraints that limit the range of possible values of the estimated parameters.

5.1.1. Measure of 'goodness of fit'

The 'goodness of fit' of the modelled to the observed data is often measured using a simple statistic. Statistics used in this study to describe the fit of final model output values to observed values include:

The root mean squared error (RMS):

$$RMS = \sqrt{\frac{\sum_{i=1}^n (W_i * (y_i - f(x_i)))^2}{n}}$$

Where:

- W_i is the i'th observation weighting
- y_i is the i'th observed value
- f(x_i) is the i'th predicted value

The scaled root mean squared error (SRMS) is the RMS divided by the range of measured heads and expressed as a percentage. Weights are sometimes introduced to account for different levels of confidence in different measurements.

$$SRMS = \frac{100}{H} \sqrt{\frac{\sum_{i=1}^n (W_i * (y_i - f(x_i)))^2}{n}}$$

Where:

- W_i are weights between 0 and 1; and
- H is the range of measured heads across the model domain.

5.2. Parameter estimation results

5.2.1. Recharge

The final scaling factor for the recharge was 0.08 which is an average rate of 128 mm/yr. This value is consistent with the recharge determined in similar environments and independent estimates of recharge using the hydrograph fluctuation method (30-180 mm, Section 3.5).

5.2.2. Hydraulic conductivity and specific yield

The hydraulic conductivity and specific yield parameter fields were defined for individual layers representing the hydrostratigraphic units developed in the Leapfrog model. The final hydraulic conductivity values are presented below in Table 5-1:

Table 5-1 Final calibrated model parameters.

LAYER	HSU	HYDRAULIC COND.	SPECIFIC YIELD
1	Zone 1 laterite / completely weathered rocks	0.1	0.015
2	Zone 2 extremely / highly / moderately weathered rocks	0.05	0.015
3	Zone 3 slightly weathered to fresh rocks	0.02	0.01

5.3. Water balance

5.3.1. Total catchment water budgets

The water balance for the entire model domain is presented below in Table 5-2. The imbalance is 342 m³ which is less than 0.001% of the inflows / outflows and several orders of magnitude less than the target criteria of <1%.

The water budget indicates that 19.6 GL/yr enters the model domain as recharge through rainfall. This is equivalent to an annual recharge rate of 117 mm based on a model domain area of 167.5 km². And is slightly higher but consistent with the range of values presented in Section 3.5.

Nearly all of the groundwater leaving the model domain 19.8 GL/yr (or 118 mm/yr) is through interception by evapotranspiration. The evapotranspiration component is consistent with the estimate provided in Section 3.6.

Table 5-2 Model domain natural water budget for the period 2010 – 2018

COMPONENT	OUT (-) [M ³]	IN (+) [M ³]	OUT [GL/YR]	IN [GL/YR]
Dirchlet	3.25E06	3.25E+00	0.3	0.0
Neumann	0.00E+00	0.00E+00	0.0	0.0
Cauchy	0.00E+00	0.00E+00	0.0	0.0
Wells	0.00E+00	0.00E+00	0.0	0.0
Distributed Sink(-) / Source(+)	2.25E+08	2.28E+08	19.6	19.8
Storage Capture(-) / Release(+)	2.04E+08	1.98E+08	17.8	17.2
Totals	4.29E+08	4.29E+08		
Imbalance		6.38E+02		

Note: The imbalance is equivalent to 1.5e-4%.

5.4. Transient model performance

Barnett et al (2012) recommend that the groundwater model acceptance should be based on a number of measures that may not be specifically related to model calibration. These measures are required to demonstrate that a groundwater model is robust, simulates the water balance as required and is consistent with the conceptual model. The four measures recommended by Barnett et al (2012) are presented below in Table 5-3. The performance of the Finnis Lithium Project BP33 model is discussed in the following sections.

Table 5-3 Recommended groundwater model performance measures (after Barnett, 2012)

PERFORMANCE MEASURE	CRITERION
Model convergence	
The model must converge in the sense that the maximum change in heads between iterations is acceptably small.	The iteration convergence criterion should be one or two orders of magnitude smaller than the level of accuracy required in head predictions. Typically, of the order of centimetres or millimetres.
Water balance	
The model must demonstrate an accurate water balance, at all times and in steady state. The water balance error is the difference between total predicted inflow and total predicted outflow, including changes in storage, divided by either total inflow or outflow and expressed as a percentage.	A value less than 1% should be achieved and reported at all times and cumulatively over the whole simulation. Ideally the error should be much less. An error of >5% would be unacceptable, and usually indicates some kind of error in the way the model has been set up.
Qualitative measures	
The model results must make sense and be consistent with the conceptual model. Contours of heads, hydrographs and flow patterns must be reasonable, and similar to those anticipated, based either on measurements or intuition. Estimated parameters must make sense, and be consistent with the conceptual model and with expectations based on similar hydrogeological systems.	Qualitative measures apply during calibration, when comparisons can be made with historical measurements, but also during predictions, when there is still a need for consistency with expectations. There is no specific measure of success. A subjective assessment is required as to the reasonableness of model results, relative to observations and expectations. The modeller should report on relevant qualitative measures and discuss the reasons for consistency and inconsistency with expectations.
Quantitative measures	
The goodness of fit between the model and historical measurements can be quantified, using statistics such as RMS, SRMS, MSR and SMSR for trial-and-error calibration and the objective function in automated calibration.	Quantitative measures only apply during calibration. Statistics of goodness of fit are useful descriptors but should not necessarily be used to define targets. Targets such as SRMS < 5% or SRMS < 10% may be useful if a model is similar to other existing models and there is good reason to believe that the target is achievable. Even if a formal target is not set, these measures may provide useful guides.

5.4.1. Model convergence

Section 4.4.2 documents that the dimensionless error criterion in FEFLOW is used for the automatic time-stepping process.

On completion of the transient model runs, the model log was queried and it was confirmed that all timesteps converged to a value less than the error criterion of 5×10^{-3} .

5.4.2. Water balance

The water balance for the entire model domain is presented above in Table 5-2. The imbalance is about 0.00015%, which is several orders of magnitude less than the Class 2 target criteria of <1%.

5.4.3. Qualitative performance

The final estimated parameters are considered to be consistent with the conceptual model and with expectations based on similar hydrogeological systems.

The modelled water budget is also considered to be consistent with the conceptual model.

The contours of heads, hydrographs and flow patterns are reasonable, and similar to those anticipated, based on observed measurements. Generally, the absolute modelled groundwater levels are in reasonably good agreement with the observed values. Long term trends in the groundwater levels are generally reproduced. The modelled vertical gradient between GWB08 / GWB10 and GWB06 / GWB07 are also generally reproduced.

The modelled and observed heads at selected sites are presented below in Figure 5-1 to Figure 5-12.

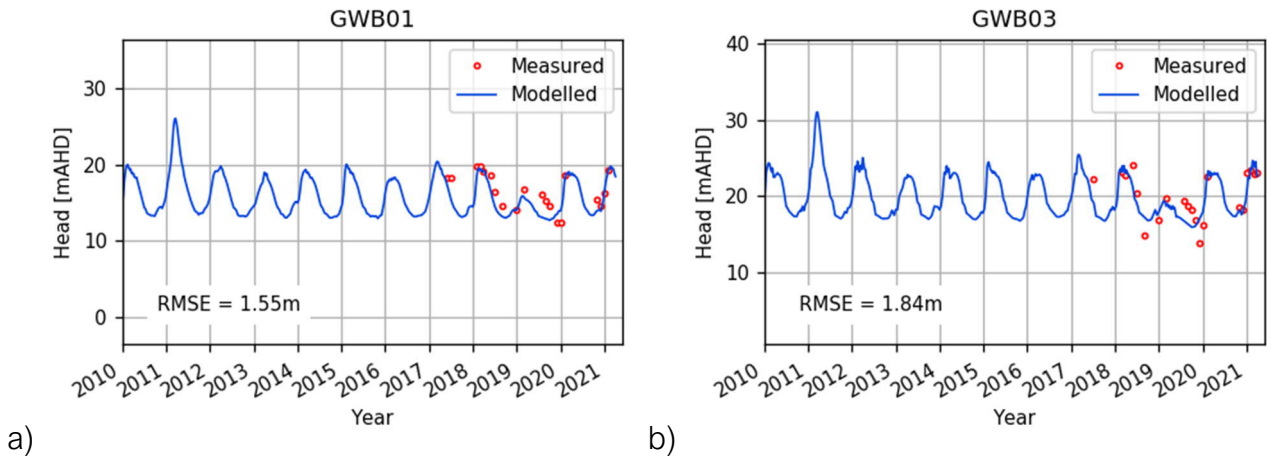


Figure 5-1 Comparison between observed and simulated groundwater levels at a) GWB01 (RN040093) b) GWB03 (RN040094).

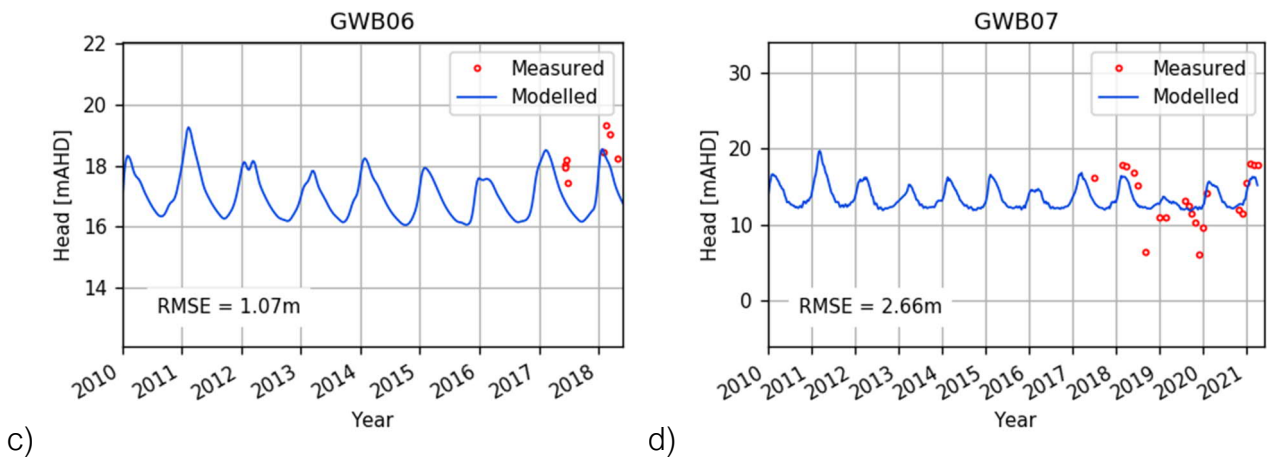
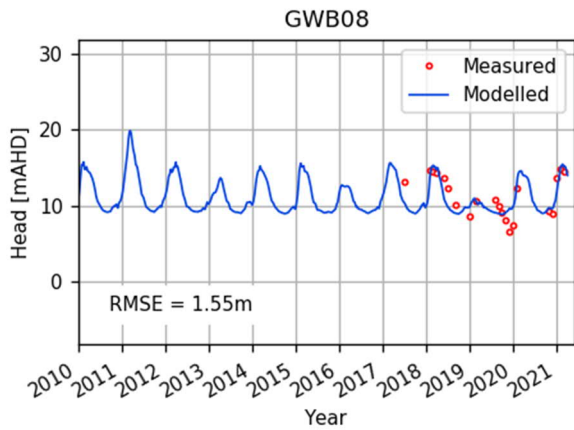
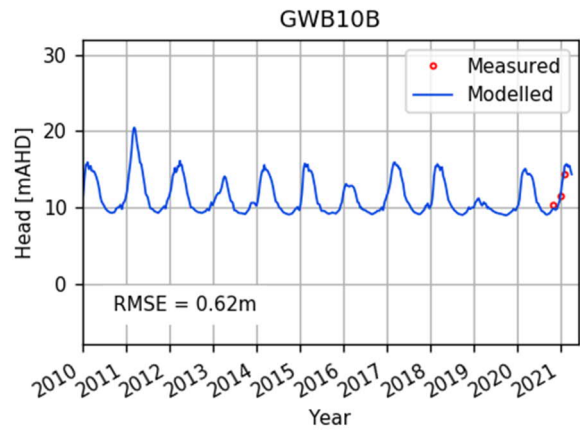


Figure 5-2 Comparison between observed and simulated groundwater levels at a) GWB06 (RN040095), b) GWB07 (RN040096).

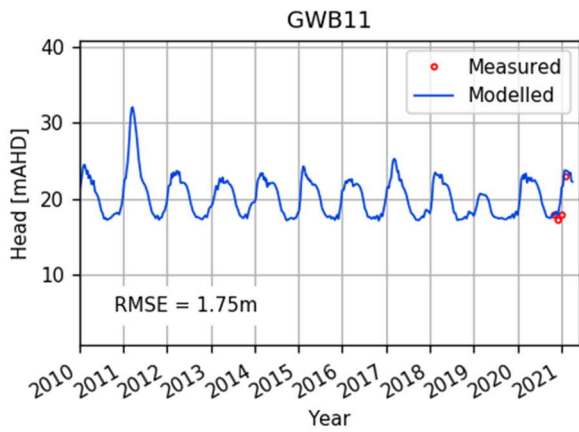


e)

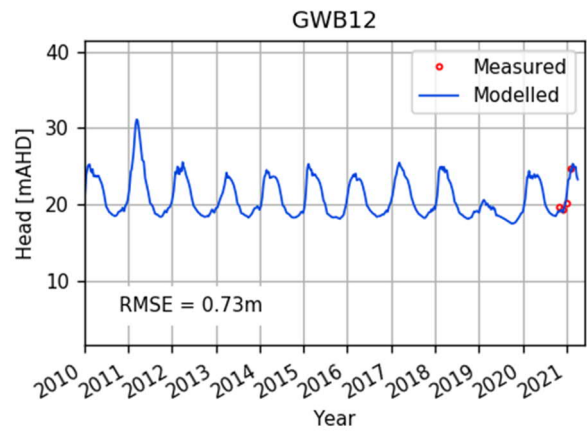


f)

Figure 5-3 Comparison between observed and simulated groundwater levels at a) GWB08 (RN040097) and b) GWB10B (RN040098).

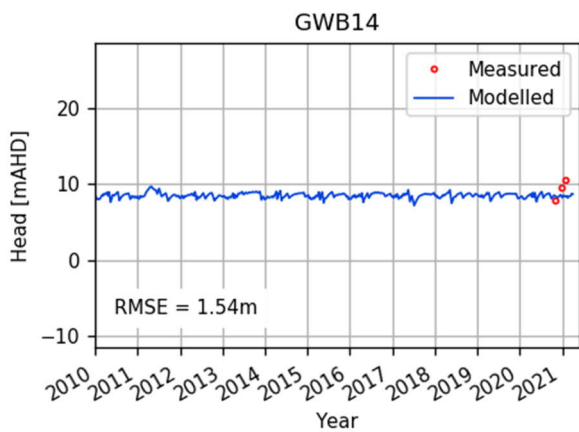


a)



b)

Figure 5-4 Comparison between observed and simulated groundwater levels at a) GWB11 (RN041837) and b) GWB12 (RN041839).



a)

Figure 5-5 Comparison between observed and simulated groundwater levels at a) GWB14 (RN041834).

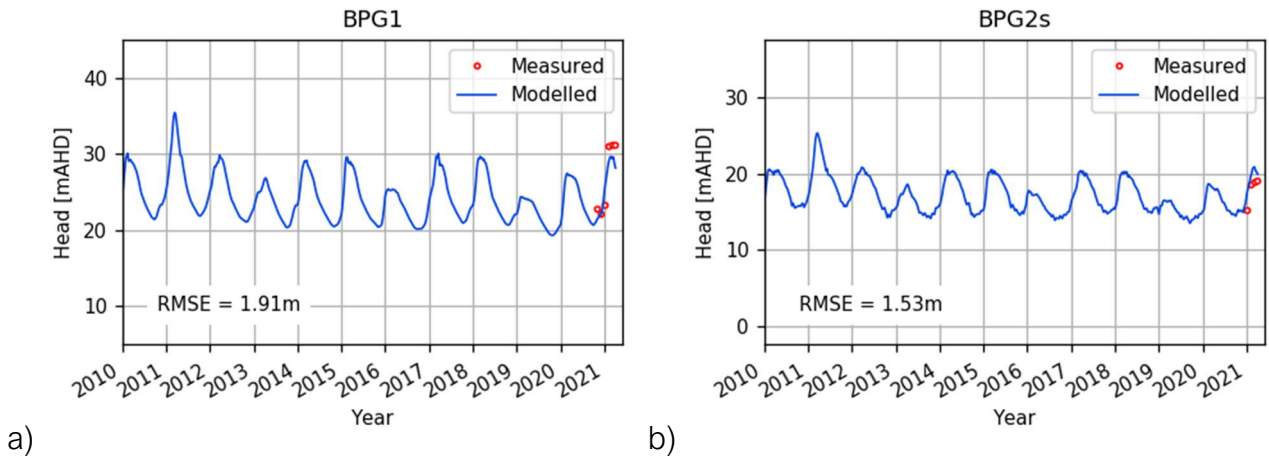


Figure 5-6 Comparison between observed and simulated groundwater levels at a) BPG1 (RN041833) and b) BPG2s (RN041792).

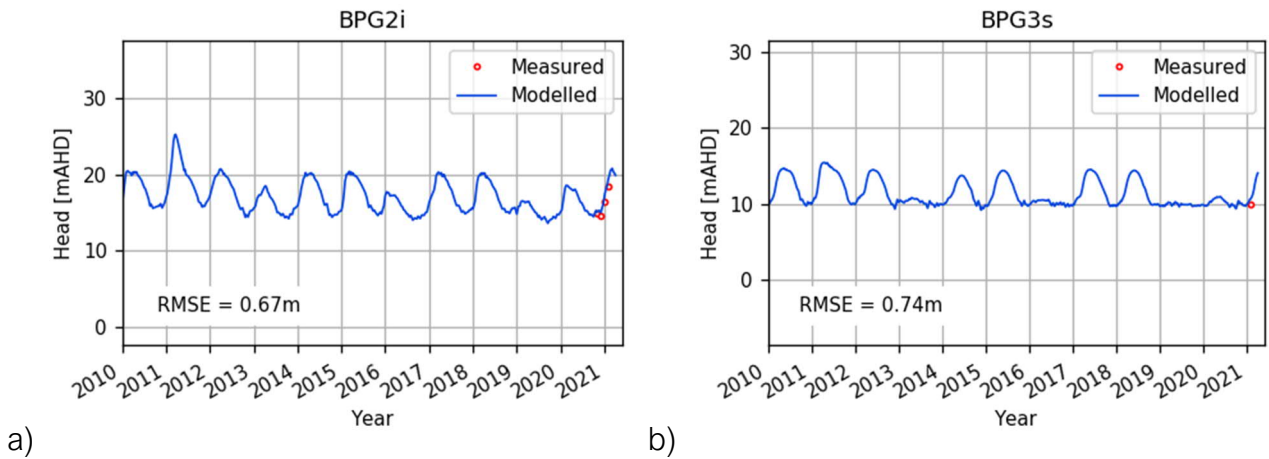


Figure 5-7 Comparison between observed and simulated groundwater levels at a) BPG2i (RN041791) and b) BPG3s (RN041794).



Figure 5-8 Comparison between observed and simulated groundwater levels at a) BPG4s (RN041832) and b) BPG4i (RN041831).

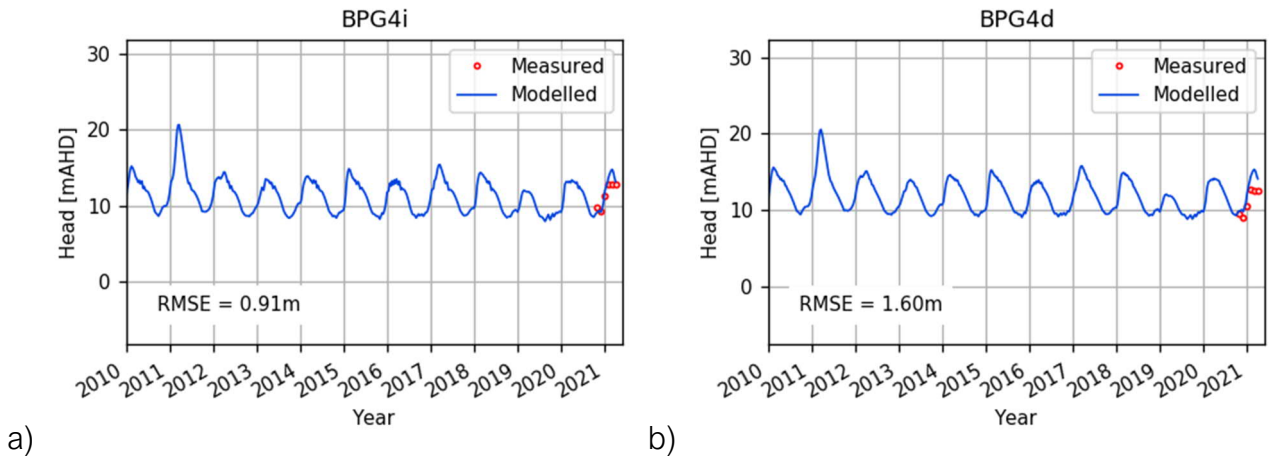


Figure 5-9 Comparison between observed and simulated groundwater levels at a) BPG4d (RN041830) and b) BPG5s (RN041795).

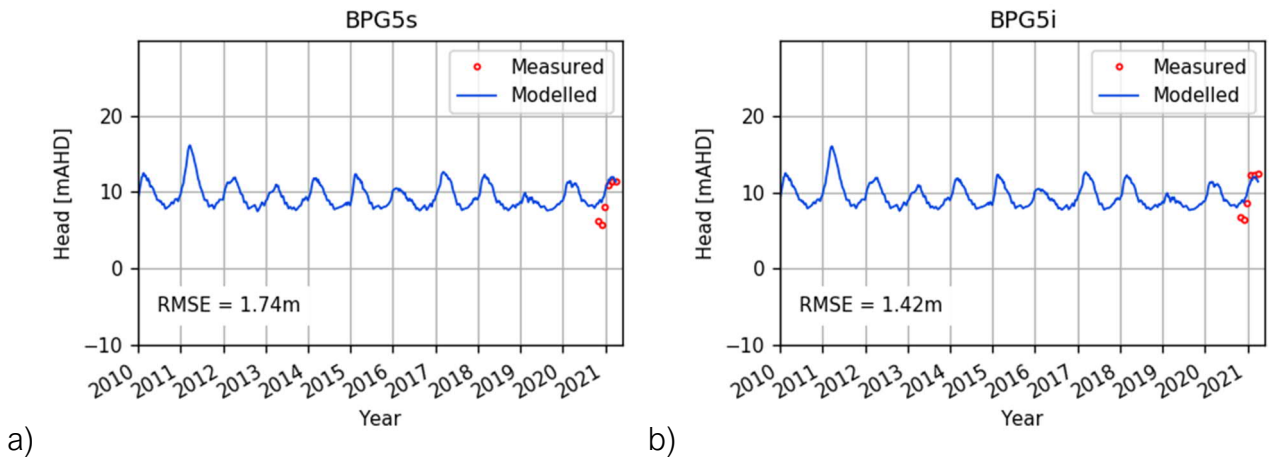


Figure 5-10 Comparison between observed and simulated groundwater levels at a) BPG5i (RN041796) and b) BPG6 (RN041799).

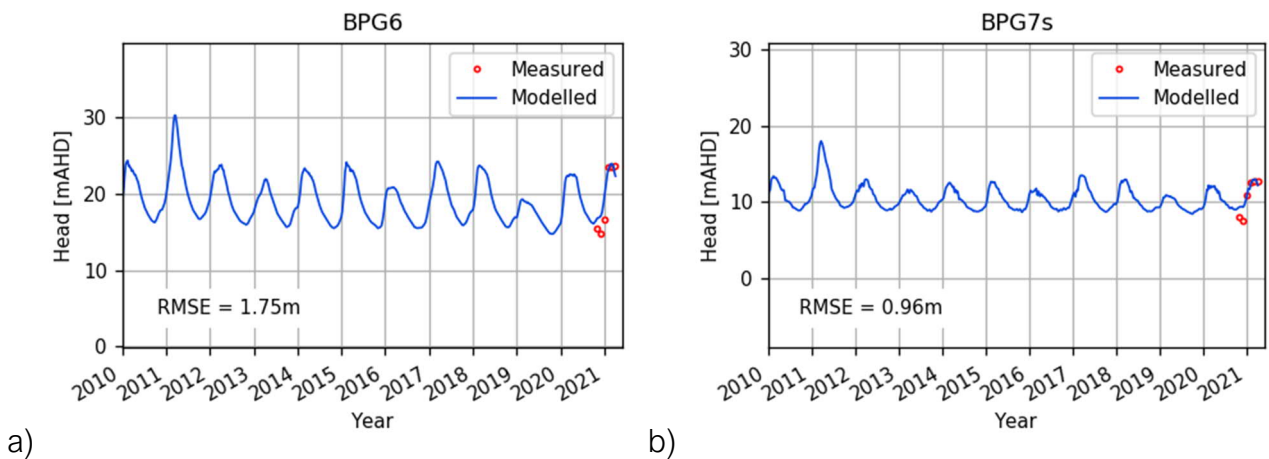


Figure 5-11 Comparison between observed and simulated groundwater levels at a) BPG7s (RN041797) and b) BPG7s (RN041797).

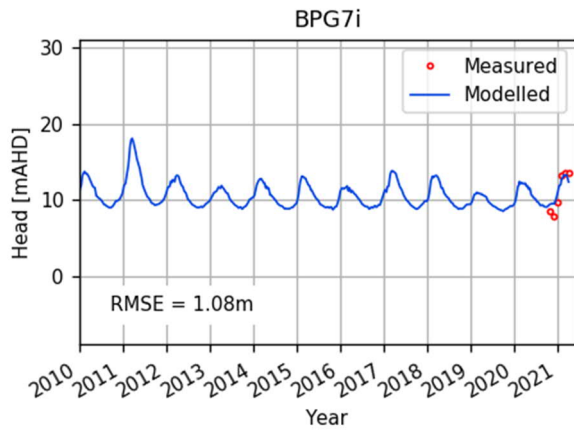


Figure 5-12 Comparison between observed and simulated groundwater levels at a) BPG7s (RN041798).

The modelled and measured heads are also presented as a scatter plot in Figure 5-13. Points below the line indicate the model is underestimating the observed value, whereas points above the line indicate the model is overestimating the groundwater levels. The scatter plot is distributed along the 1:1 fit and points are distributed either side of the line indicating no systemic bias of modelled results.

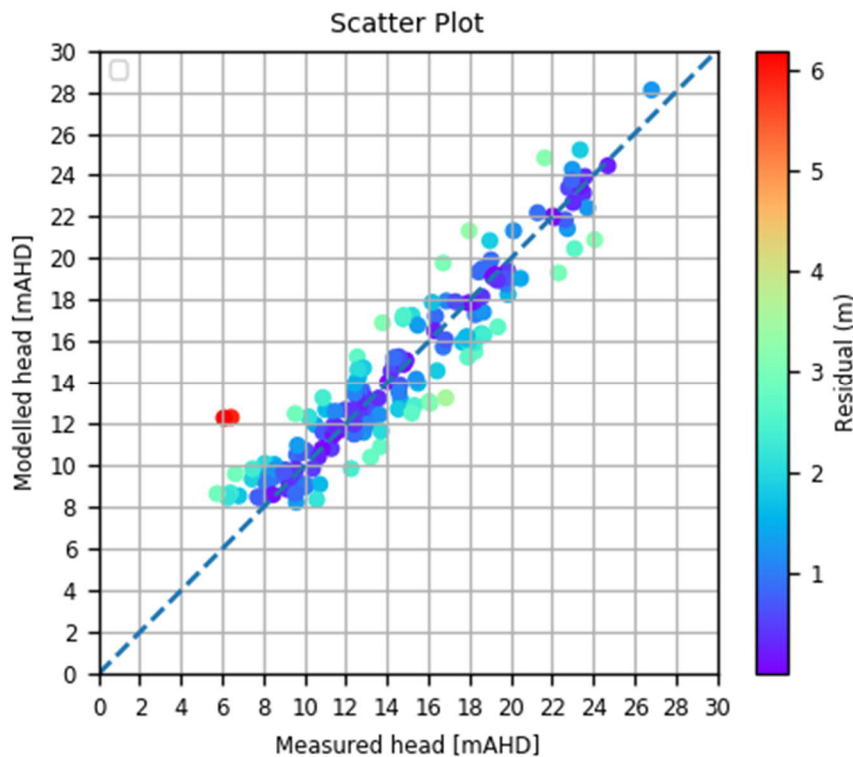


Figure 5-13 Scatter plot of modelled vs measured heads. The point colour indicates the magnitude of the residuals (i.e. the absolute difference between measured and modelled heads).

5.4.4. Quantitative performance

At the conclusion of the parameter estimation process the final standard error (RMS) of 1.67 metres. Maximum observed head was 31.2 metres, minimum observed head is 5.75 metres.

The maximum head range of the observed heads is 25.5 metres, therefore, the scaled root mean squared (SRMS) is 6.6% (slightly above the nominal target SRMS of 5%).

Statistical descriptions of the goodness of fit between the observed and modelled groundwater levels are presented in Table 5-4.

Table 5-4 Analysis of residuals using final estimated parameters.

METRIC	ALL OBS.
Number of residuals with non-zero weight	171
Mean value of non-zero weighted residuals	0.08
Maximum weighted residual	6.2
Minimum weighted residual	3.6
Standard variance of weighted residuals	2.8m
Standard error of weighted residuals (RMS)	1.67m
Scaled standard error (SRMS)	6.6%

6 Forecast model results

This section investigates the impacts of the BP33 box-cut and underground workings, and the cumulative impacts of the Grants Lithium Project (GLP) pit development over the life of the mine and post closure during the development of the pit-lake. The scenarios considered are summarised below:

- Life of mine (60 months – 5 years)
- Post closure (70 years)

6.1. Life of mine (LoM) forecast

The life of mine (LoM) forecast scenario was designed to investigate the effect of the BP33 box-cut and underground workings development on groundwater flow dynamics in the area including cumulative impacts from the GLP pit. The following assumptions were made for the predictive model runs:

- All model parameters were taken from the calibrated model;
- Pit shell elevations were applied to the model as detailed in Section 2;
- Passive groundwater dewatering via sumps, with no groundwater dewatering from production bores;
- The model was run for a forecast period of 60 months from the end of the calibration period (Month 0) to the projected end of the mining (Month 59).
- Initial conditions were taken from the final heads of the calibrated model corresponding to 44348d (01/06/2021);
- The time series climatic inputs from the period 1900 – 2000 were repeated to obtain the 100 year time series used to calculate recharge for the forecast post closure model.

6.2. Groundwater levels LoM and 60 months post closure

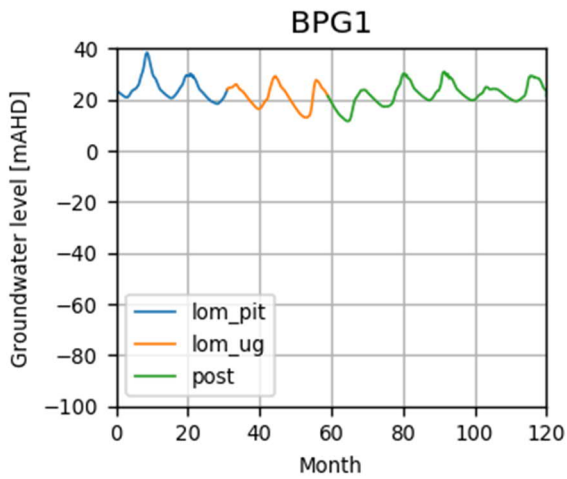
The groundwater level response for bores installed around the BP33 project and the GLP are presented for the 5 year (60 month) life of mine period and an additional 5 years (60 month) post closure period.

6.2.1. BP33 groundwater levels

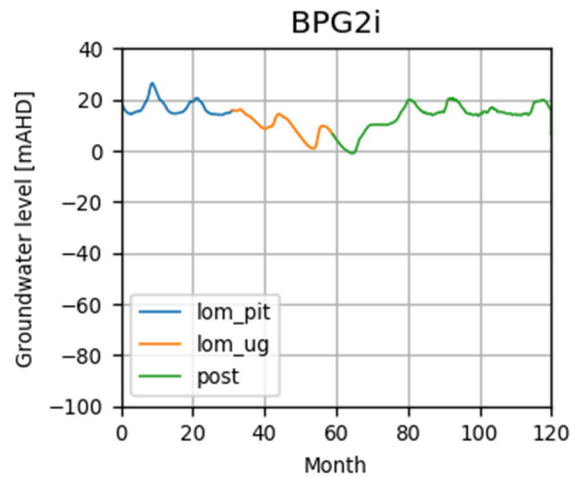
The life of mine (LoM) groundwater levels in the bores around the BP33 box-cut, decline and underground workings are presented below in Figure 6-1 through to Figure 6-7. On the basis of these hydrographs, and the drawdown plot presented in **Error! Reference source not found.**, it is estimated that groundwater levels around BP33 will recover to pre-mining levels within 3 years of mine activities finishing.

These predictions assume that the underground mine and decline are left predominantly as mine voids and that the box-cut is backfilled with material that has a specific yield of 10%. This is a substantially higher storage value than adopted in the modelling for the undisturbed, weathered Burrell Creek Formation ($S_y = 1.5\%$). The higher storage value has been adopted to account for the disturbance of the backfill material during excavation. Currently the storage properties of the backfill material are unknown, however, higher storage properties associated with the voids between backfilled waste rock will result in a greater period of recovery.

Model Results

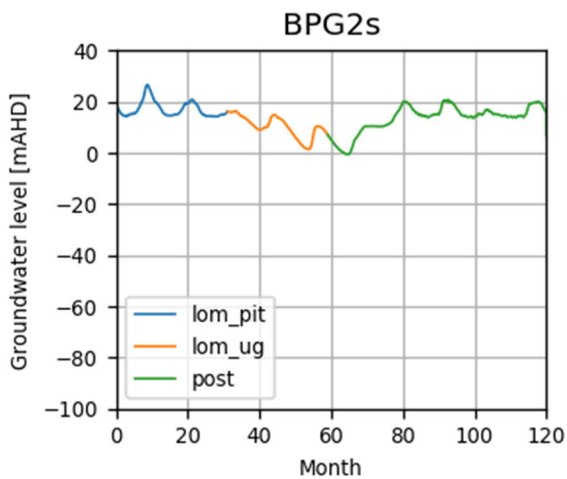


a)

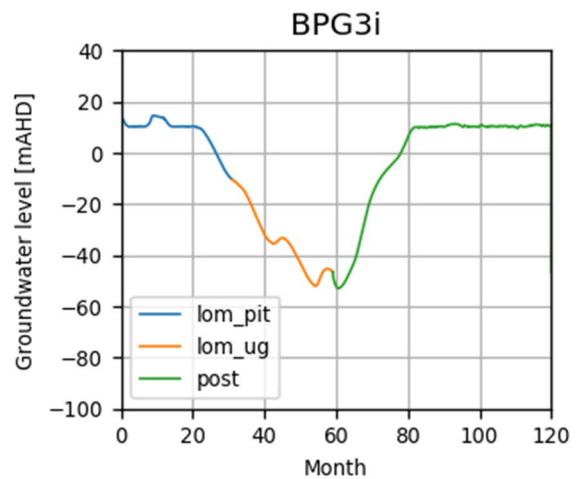


b)

Figure 6-1 Groundwater response during LoM to 60 months post mining at bores a) BPG1 and b) BPG2i.

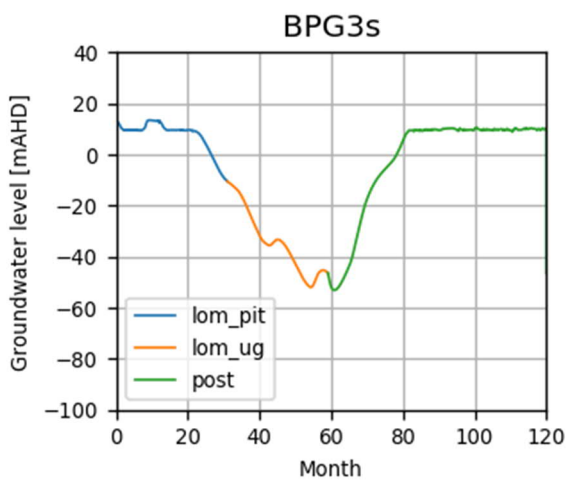


a)

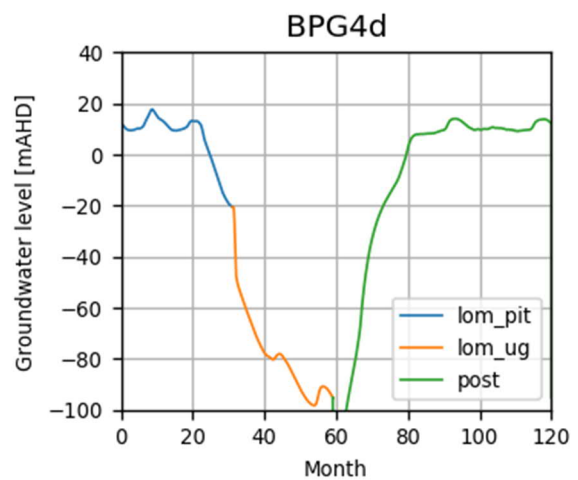


b)

Figure 6-2 Groundwater response during LoM to 60 months post mining at bores a) BPG2s and b) BPG3i.



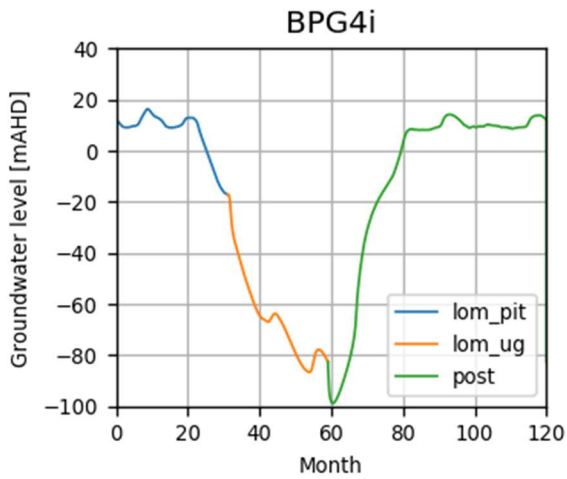
a)



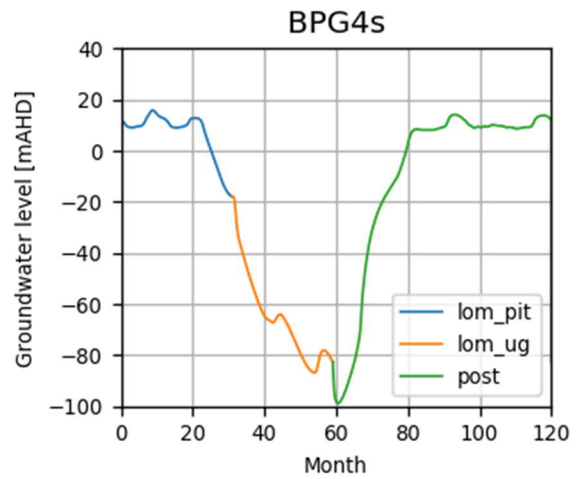
b)

Figure 6-3 Groundwater response during LoM to 60 months post mining at bores a) BPG3s and b) BPG4d.

Model Results

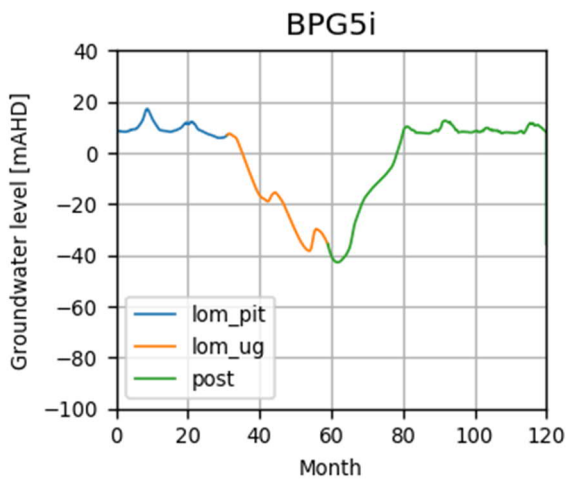


a)

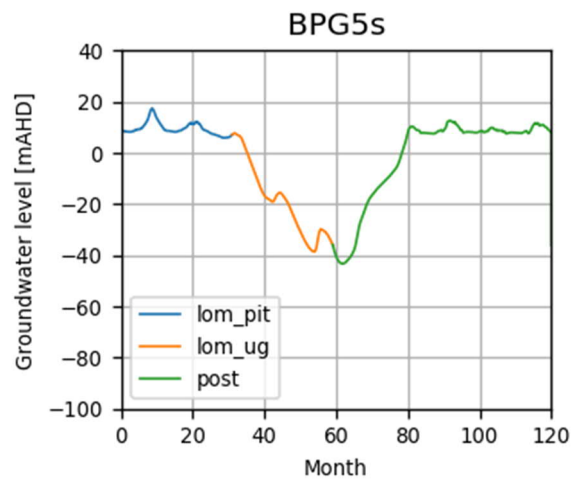


b)

Figure 6-4 Groundwater response during LoM to 60 months post mining at bores a) BPG4i and b) BPG4s.

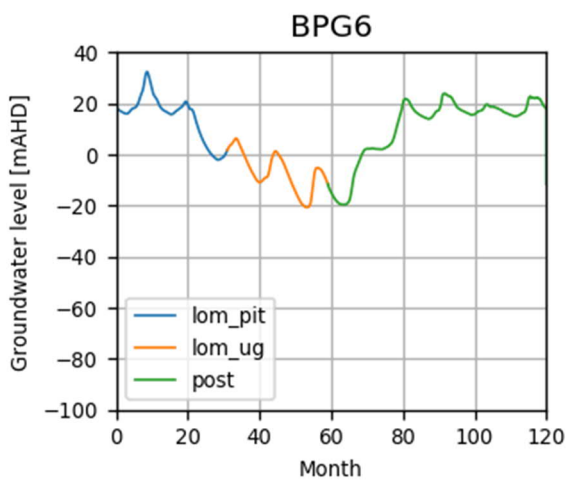


a)

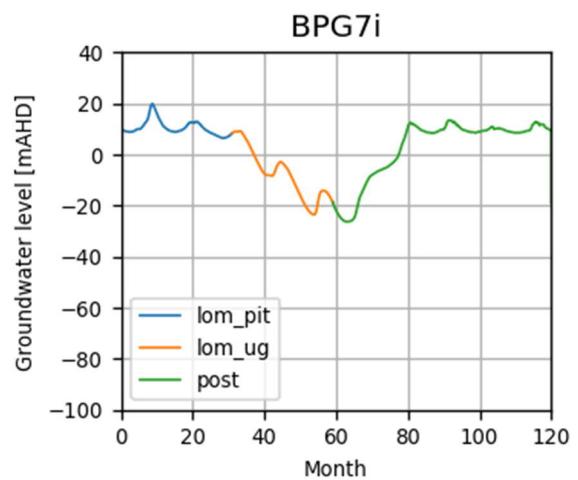


b)

Figure 6-5 Groundwater response during LoM to 60 months post mining at bores a) BPG5i and b) BPG5s.



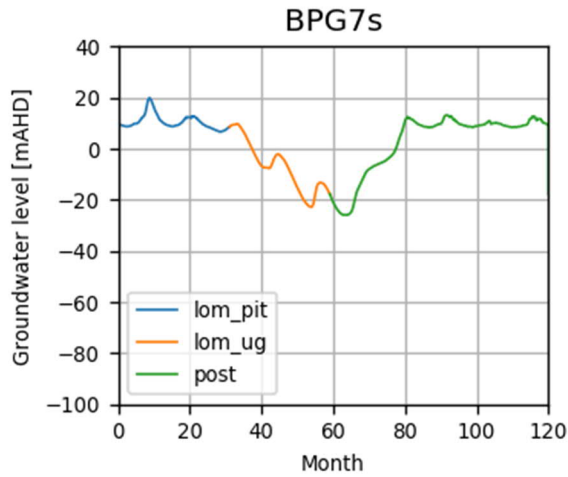
a)



b)

Figure 6-6 Groundwater response during LoM to 60 months post mining at bores a) BPG6 and b) BPG7i.

Model Results



a)

Figure 6-7 Groundwater response during LoM to 60 months post mining at bore a) BPG7s.

6.2.2. Grants groundwater levels

The life of mine (LoM) groundwater levels in the bores around the GLP pit are shown in Figure 6-8 through to Figure 6-12.

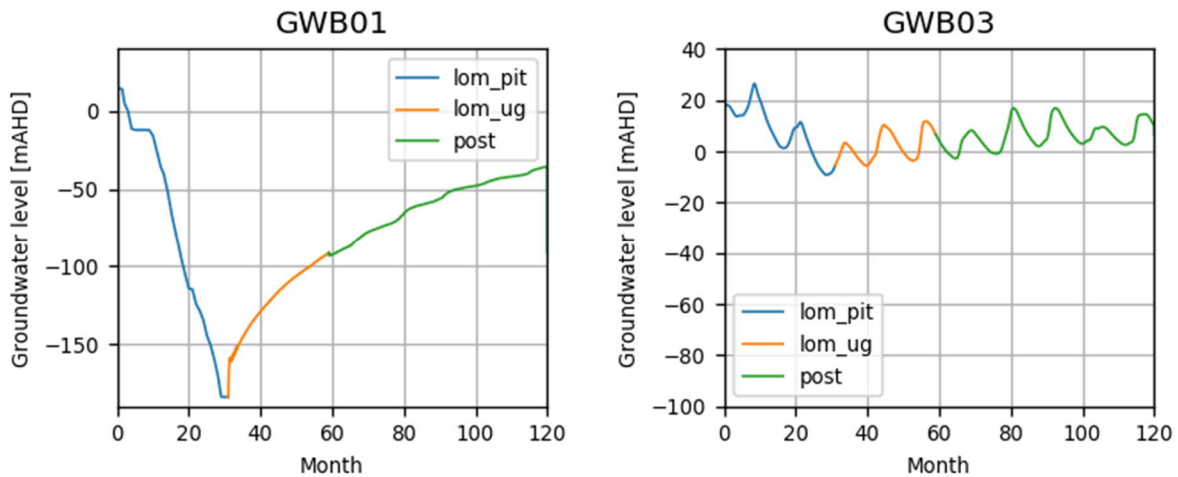


Figure 6-8 Groundwater response during LoM to 60 months post mining at existing observation bores a) GWB01 and b) GWB03.

Model Results

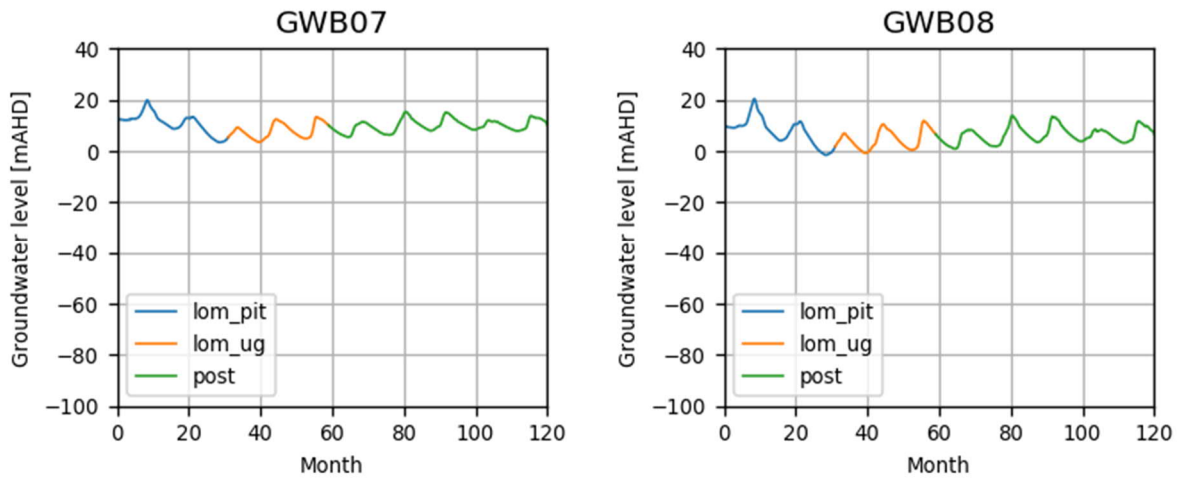


Figure 6-9 Groundwater level response during LoM and 60 months post mining at existing observation bores a) GWB07 and b) GWB08.

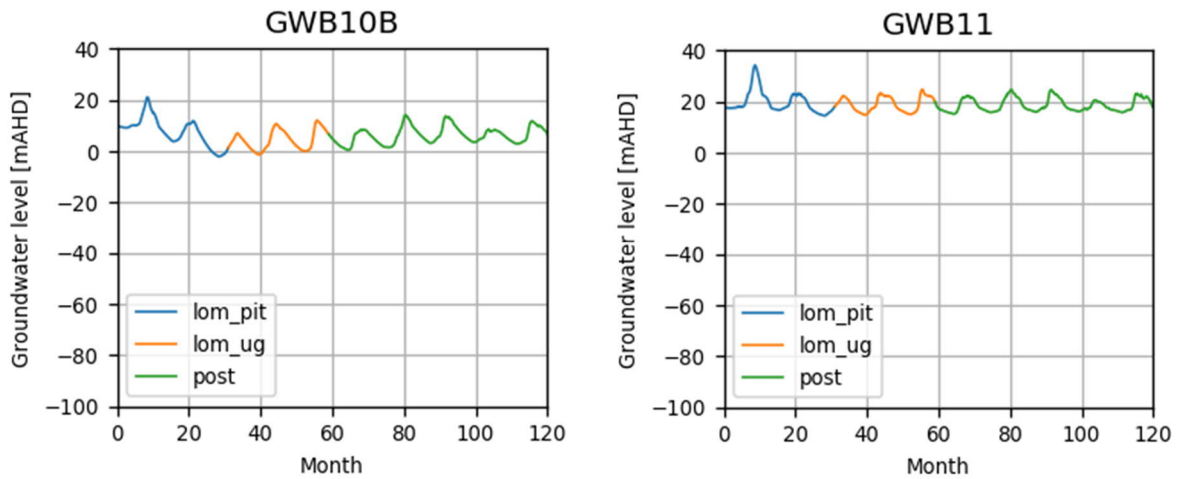


Figure 6-10 Groundwater level response during LoM and 60 months post mining at existing observation bores a) GWB10b and b) GWB11.

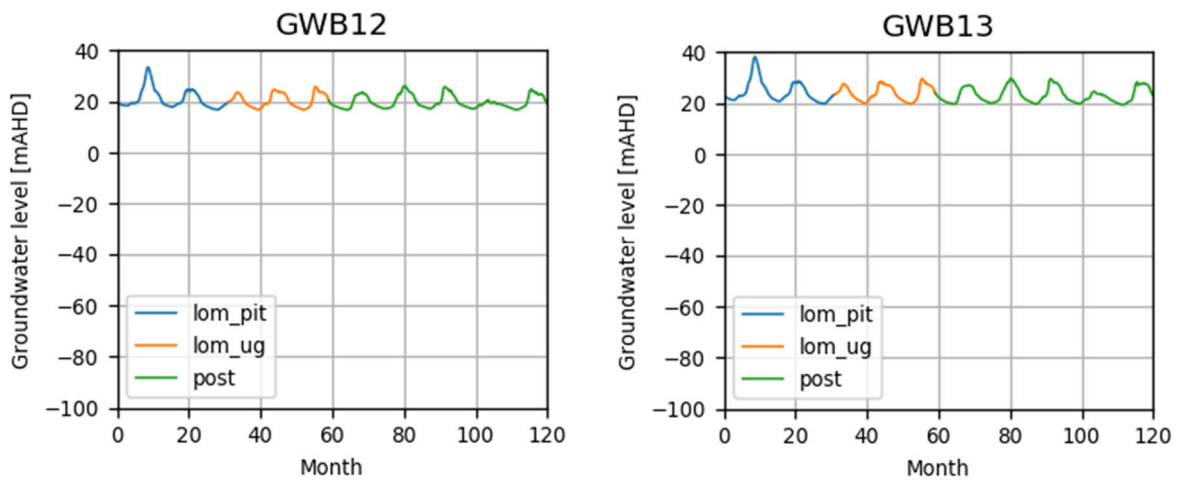


Figure 6-11 Groundwater level response during LoM and 60 months post mining at existing observation bores a) GWB12 and b) GWB13.

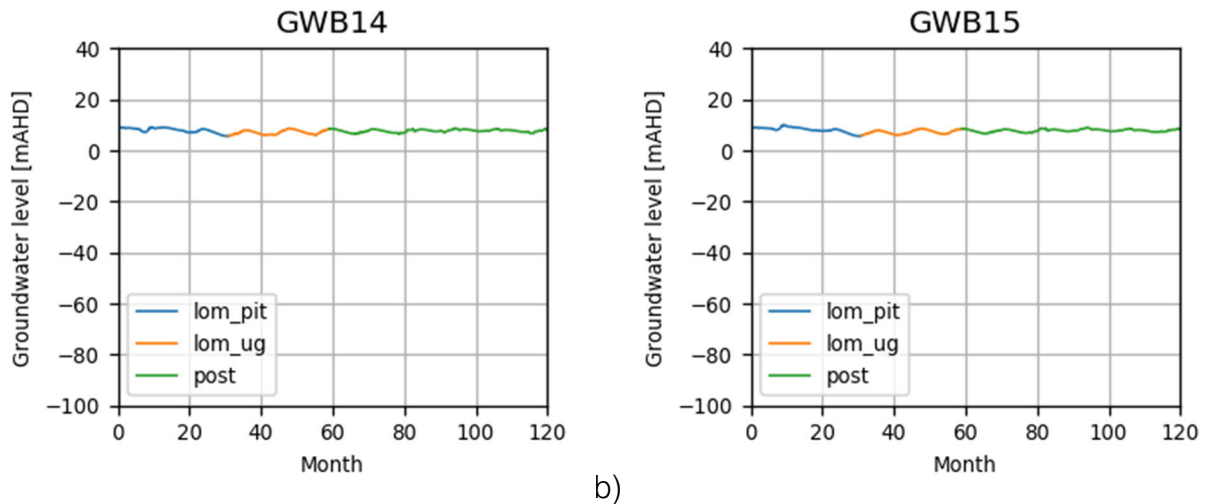


Figure 6-12 Groundwater level response during LoM and 60 months post mining at existing observation bores a) GWB14 and b) GWB15.

6.2.3. Groundwater drawdown contours

The LoM forecast drawdown impacts at the end of the 30 month mining period at the GLP pit, and at the end of underground mining at BP33 (month 60), are presented below in Figure 6-13 and Figure 6-14 respectively.

The predicted drawdown cone resulting from the pit dewatering at the GLP extends towards the mining lease boundary in the north, west and east. In the south-west the 0.1 m drawdown contour approaches the upstream end of an ephemeral drainage line. In all other respects the drawdown is similar to the original GLP model (CloudGMS, 2018) in that it is contained within the mining lease.

The drawdown cone associated with the BP33 mine activities extends beyond the eastern and southern edges of the mining lease. This drawdown is associated with excavation of the box-cut. The drawdown also extends below the areas identified with moderate potential for GDEs. Anecdotally there is some indication that surface pools of water along the drainage line persist through some dry seasons suggesting there is some groundwater dependence. However, the extent of dependence of the GDEs on groundwater is not currently characterised. These ecosystems are likely facultative GDEs, with an infrequent or partial dependence on groundwater.

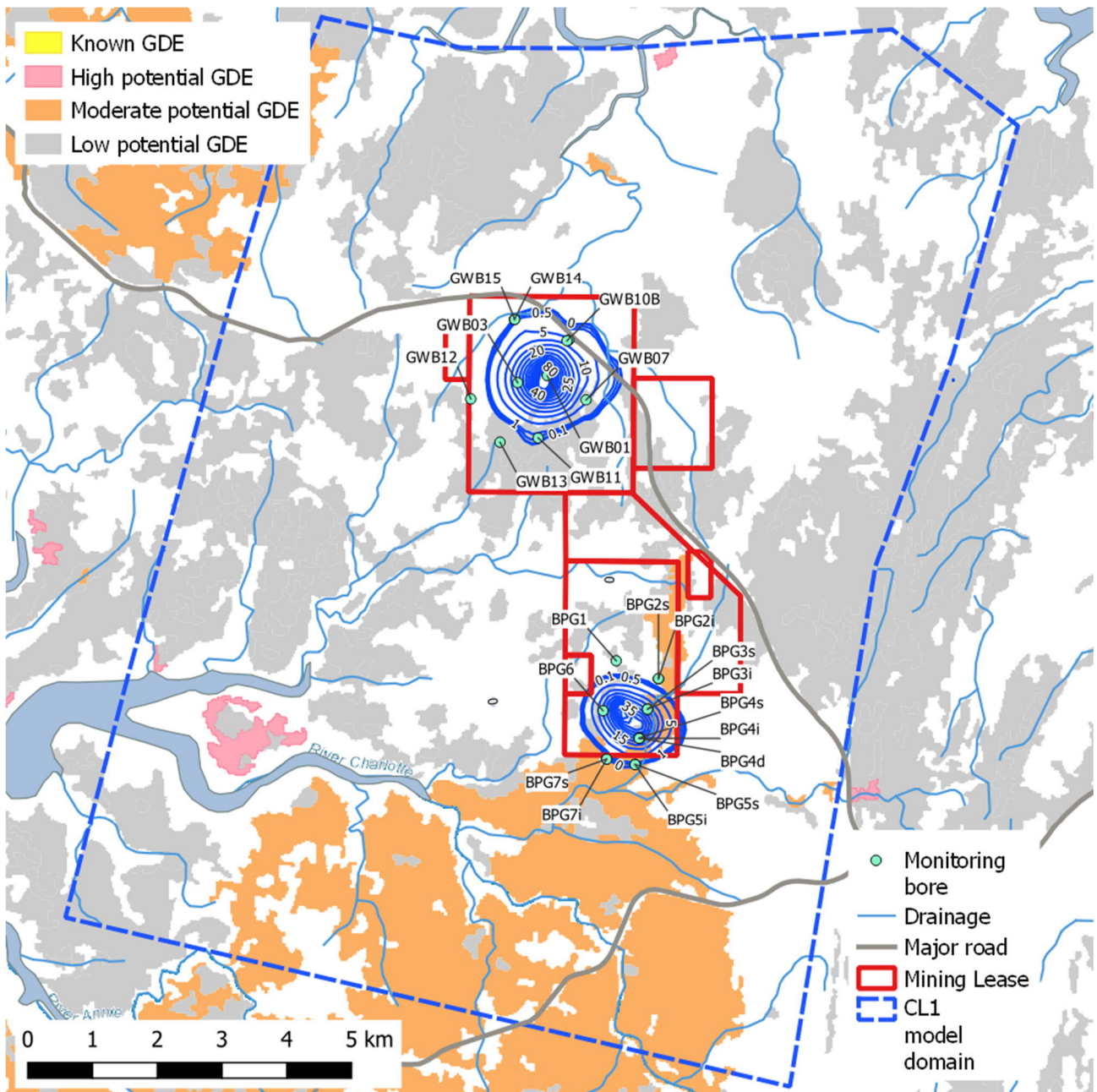


Figure 6-13 Cumulative LoM final drawdown contours after 30 months of mining at the end of mining at Grants pit and after excavation of the box cut and decline at BP33.

Model Results

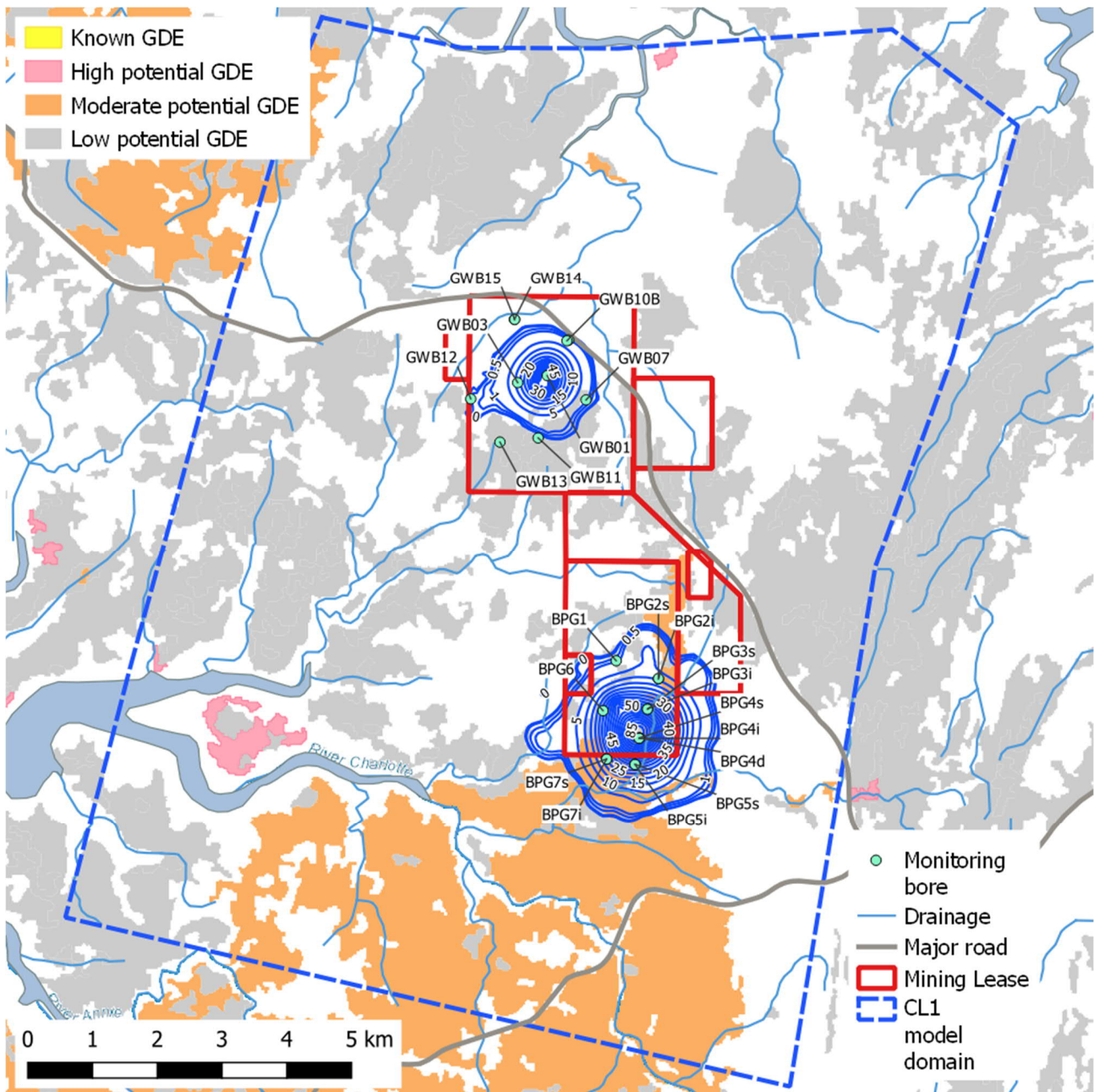


Figure 6-14 Cumulative LoM final drawdown contours after 60 months of mining (30 months recovery at the Grants pit).

6.2.4. Life of Mine inflows

The BP33 box-cut, decline and underground mine workings inflows have been determined during the life of mine and are presented below. Inflows to the mine components, expressed as kL/month, are presented below for the box-cut, decline, underground, Grants pit and as total cumulative inflows in Figure 6-15a, Figure 6-15b, Figure 6-16a, Figure 6-16b and Figure 6-17 respectively. Inflows to these components of the BP33 project are briefly described below:

- Inflows at the BP33 box-cut increase from commencement of excavation in month 17 and reach a peak in month 20 at about 2400 kL/d (28 L/s). Inflows to the box-cut steadily

Model Results

decline to less than 330 kL/d (4 L/s) in month 50 to the end of mining. BP33 box-cut inflows as kL/month over the LoM are presented graphically in Figure 6-15a.

- Inflows from the BP33 decline increase from commencement of excavation in month 23 and reach a peak in month 47 at about 2900 kL/d (34 L/s). Inflows to the decline are steady to the end of mining. BP33 decline inflows as kL/month over the LoM are presented graphically in Figure 6-15b.
- Inflows at BP33 underground increase from commencement of mining in month 31 and reach a peak in month 58 at about 3860 kL/d (45 L/s). Inflows to the underground mine as kL/month over the LoM are presented graphically in Figure 6-16a.
- At the end of mining at Grants Pit, groundwater discharges to the pit and it fills to form a pit lake. The inflows to the pit lake decline steadily from around 2800 kL/d to 2500 kL/d as the groundwater gradient towards the pit reduces as the pit lake fills.

Total cumulative inflows are presented in Table 6-1 and graphically in Figure 6-17.

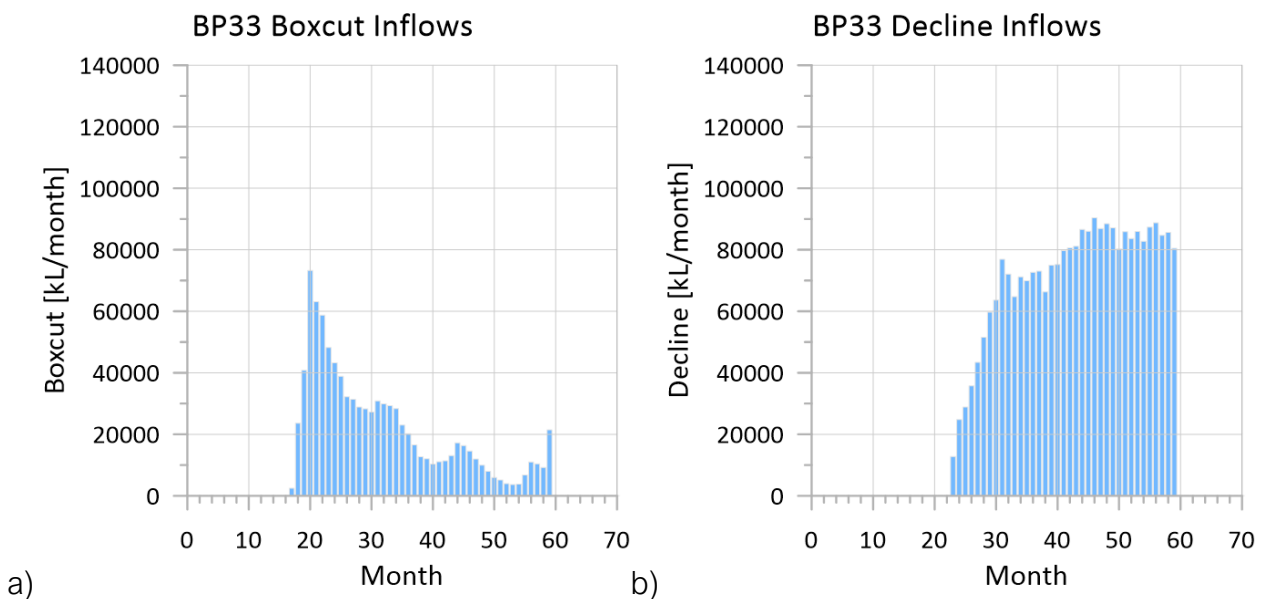


Figure 6-15 Predicted a) BP33 box-cut and b) BP33 decline inflows (kL/month) during life of mine.

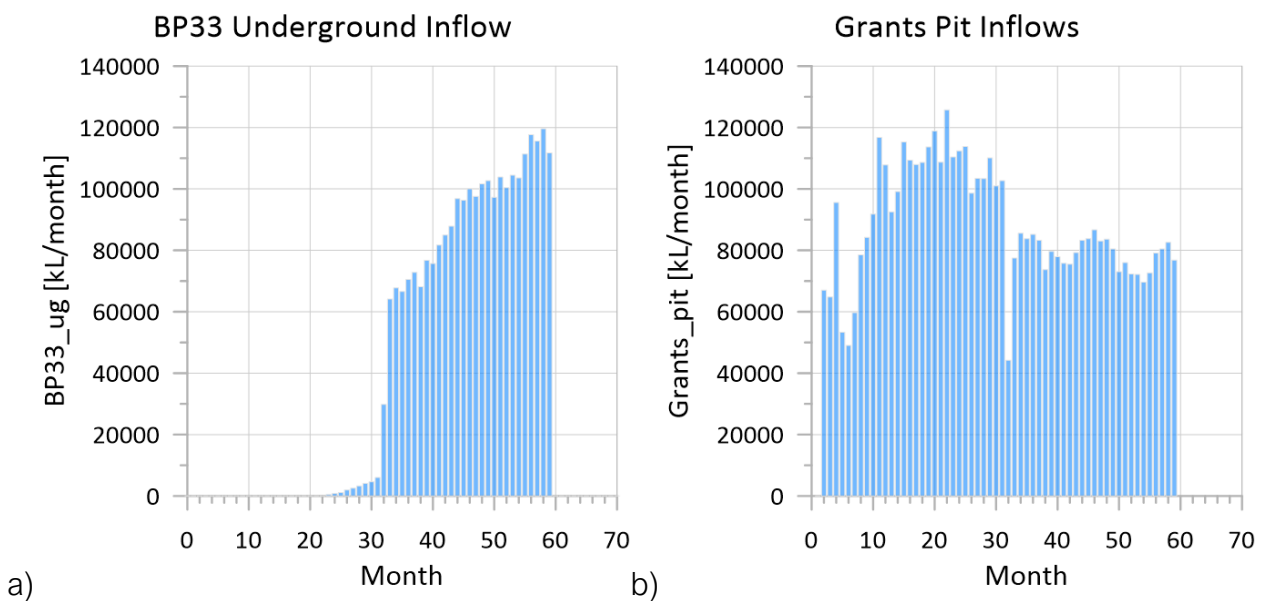


Figure 6-16 Predicted a) BP33 underground mine and b) Grants pit inflows (kL/month) during life of mine.

Model Results

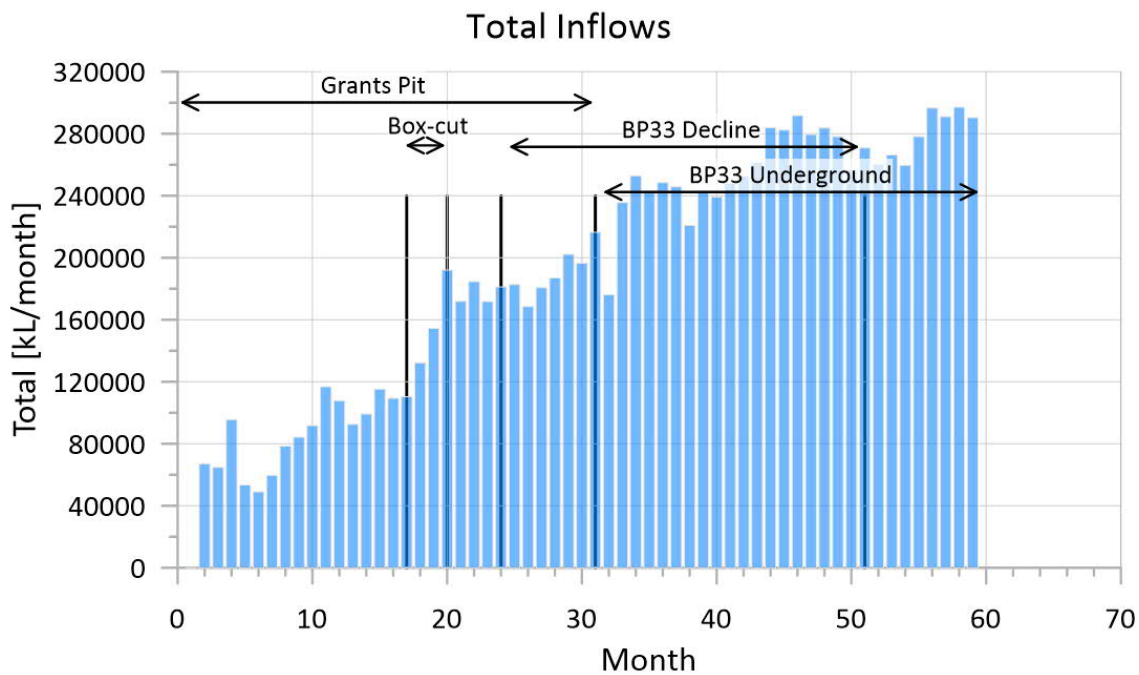


Figure 6-17 Predicted total inflows during life of mine.

Table 6-1 Monthly life of mine inflows expressed as kL/m and kL/d.

Month	Box-cut kL/m	Decline kL/m	BP33 kL/m	Grants_ pit kL/m	Total kL/m	Box-cut kL/d	Decline kL/d	BP33 kL/d	Grants_ pit kL/d	Total kL/d
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	67064	67064	0	0	0	2313	2313
3	0	0	0	64814	64814	0	0	0	2091	2091
4	0	0	0	95615	95615	0	0	0	3187	3187
5	0	0	0	53352	53352	0	0	0	1721	1721
6	0	0	0	49063	49063	0	0	0	1635	1635
7	0	0	0	59675	59675	0	0	0	1925	1925
8	0	0	0	78546	78546	0	0	0	2534	2534
9	0	0	0	84228	84228	0	0	0	2808	2808
10	0	0	0	91801	91801	0	0	0	2961	2961
11	0	0	0	116758	116758	0	0	0	3892	3892
12	0	0	0	107839	107839	0	0	0	3479	3479
13	0	0	0	92555	92555	0	0	0	2986	2986
14	0	0	0	99139	99139	0	0	0	3541	3541
15	0	0	0	115280	115280	0	0	0	3719	3719
16	0	0	0	109359	109359	0	0	0	3645	3645
17	2460	0	0	107947	110407	79	0	0	3482	3562
18	23604	0	0	108618	132221	787	0	0	3621	4407
19	40771	0	0	113704	154476	1315	0	0	3668	4983
20	73286	0	0	118844	192130	2364	0	0	3834	6198
21	63130	0	0	108698	171828	2104	0	0	3623	5728
22	58761	0	0	125776	184537	1896	0	0	4057	5953
23	48185	12784	455	110375	171799	1606	426	15	3679	5727

Model Results

Month	Box-cut kL/m	Decline kL/m	BP33 kL/m	Grants_ pit kL/m	Total kL/m	Box-cut kL/d	Decline kL/d	BP33 kL/d	Grants_ pit kL/d	Total kL/d
24	43239	24765	818	112408	181229	1395	799	26	3626	5846
25	38860	28834	1136	113848	182677	1254	930	37	3673	5893
26	32168	35780	1978	98655	168581	1111	1236	68	3408	5823
27	31371	43365	2584	103449	180769	1044	1443	86	3443	6016
28	28838	51537	3263	103374	187012	961	1718	109	3446	6234
29	28283	59718	4072	110117	202190	912	1926	131	3552	6522
30	27236	63658	4652	100963	196509	908	2122	155	3365	6550
31	30883	76921	6010	102677	216491	973	2424	189	3236	6823
32	29933	72053	29855	44247	131841	989	2380	986	1461	5816
33	29288	64754	64173	77468	158214	976	2158	2139	2582	7855
34	28354	71165	67763	85556	167282	915	2296	2186	2760	8157
35	23008	69933	66596	83784	159537	767	2331	2220	2793	8111
36	20160	72646	70536	85207	163341	650	2343	2275	2748	8016
37	16569	73032	72861	83281	162461	534	2356	2350	2686	7926
38	12711	66278	68172	73707	147161	454	2367	2435	2633	7889
39	12006	74965	76751	79676	163722	387	2418	2476	2570	7851
40	10324	75223	75718	77916	161264	344	2507	2524	2597	7972
41	11062	79692	81707	75777	172461	357	2571	2636	2445	8009
42	11359	80639	84983	75525	176982	368	2616	2756	2449	8189
43	13112	81125	87892	79243	182130	435	2689	2913	2626	8663
44	17237	86615	96818	83283	200670	556	2794	3123	2686	9159
45	16315	86021	96304	83791	198641	544	2867	3210	2793	9414
46	14591	90378	100015	86668	204983	471	2915	3226	2795	9407
47	11999	86905	97591	83031	196496	400	2897	3253	2768	9318
48	9967	88453	101643	83661	200062	322	2853	3279	2699	9153
49	7952	87133	102692	80434	197777	257	2811	3313	2595	8976
50	5973	80319	97299	73026	183591	206	2770	3355	2518	8849
51	5129	85857	103858	76006	194844	165	2770	3350	2452	8737
52	3976	83656	100367	72319	187999	133	2789	3346	2411	8679
53	3686	85923	104493	72162	194102	119	2772	3371	2328	8590
54	3805	82766	103582	69605	190154	127	2759	3453	2320	8659
55	6766	87381	111356	72671	205502	218	2819	3592	2344	8973
56	11015	88778	117682	79157	217474	355	2864	3796	2553	9568
57	10382	84717	115563	80439	210661	346	2824	3852	2681	9703
58	9238	85649	119611	82602	214498	298	2763	3858	2664	9583
59	21424	80428	111741	76822	213592	699	2624	3646	2507	9476

6.3. 70 year post closure forecast

The post closure impacts scenario was based on the life of mine scenario with the following additional assumptions / settings:

- Initial heads were taken from the final time step of the LoM scenario;
- The post closure model runs for an additional 70 years;
- IfmLake module (CloudGMS, 2018 s4.3.5) was used to simulate the filling of the pit void.
- Removing the seepage face boundary conditions associated with the underground mine.
- Material properties of the elements representing the underground mine and decline were adjusted to reflect the void space remaining at the end of mining.
- Material properties of the elements representing the box-cut backfill are an order of magnitude greater than the in-situ basement rocks to characterise voids between backfill material (i.e $S_y = 10\%$).

The post closure period of 70 years was determined from previous modelling (CloudGMS, 2018).

The seasonal nature of recharge meant that a steady state model of the system was not deemed appropriate to assess the post closure impacts. The model was run to an approximate dynamic equilibrium which is represented as a stabilisation of groundwater levels, pit-lake levels and inflows to the pit.

6.3.1. Groundwater drawdown contours

Drawdown contours are presented at 3 years post closure and 70 years post closure in Figures 6-18 and Figure 6-18. Around BP33 the watertable surface is predicted to recover to pre-mining levels within 3 years of the mine closure (Figure 6-18). No long-term changes to the watertable surface are predicted after mine closure and rehabilitation.

At the GLP, the pit lake operates as a groundwater sink and will result in 0.5 m drawdown with a radial extent of approximately 750 m around the pit lake. The change in watertable surface resulting from the mining activities and the pit lake extends marginally beyond the western boundary of the mining lease. The predicted area of watertable change does not extend beneath ephemeral drainage lines. As a consequence, the development of the legacy pit lake is not anticipated to affect groundwater availability to riparian zone vegetation.

6.3.2. Impacts to existing users and environmental receptors from drawdown

Based on the forecast scenarios, over the 70 year period considered by the groundwater flow modelling no watertable drawdown impacts are predicted beyond the BP33 mining lease or underneath the ephemeral water course that drain the BP33 site.

No impacts are predicted to existing groundwater users - the nearest of which is over 4 km from the site – or long-term impacts on groundwater dependent ecosystems from the underground dewatering activities. For the life of the mine to around 3 years post closure impacts are predicted on groundwater availability in areas of the BP33 lease.

At BPG2, located on the northern edge of the impacted moderate potential GDE areas, the depth to groundwater is likely to be below the depth accessible by vegetation for around 3 to 4 years (from month 30 to month 70-80).

Model Results

The groundwater modelling sites BPG3 and BPG4, located on the edge of the moderate potential GDE areas, show that depth to groundwater in the weathered BCF is likely to be below the depth accessible by vegetation for approximately 5 years (from month 20 to month 80).

Figure 6-14 indicates that the maximum area affected is around 1.8 km². However, this area will reduce if a particular drawdown value is assumed to represent the depth to groundwater that vegetation can no longer access (e.g. drawdown of 5 m at the end of mining impacts an area of 1.15 km², which corresponds to a reduction of 36% from the maximum predicted area).

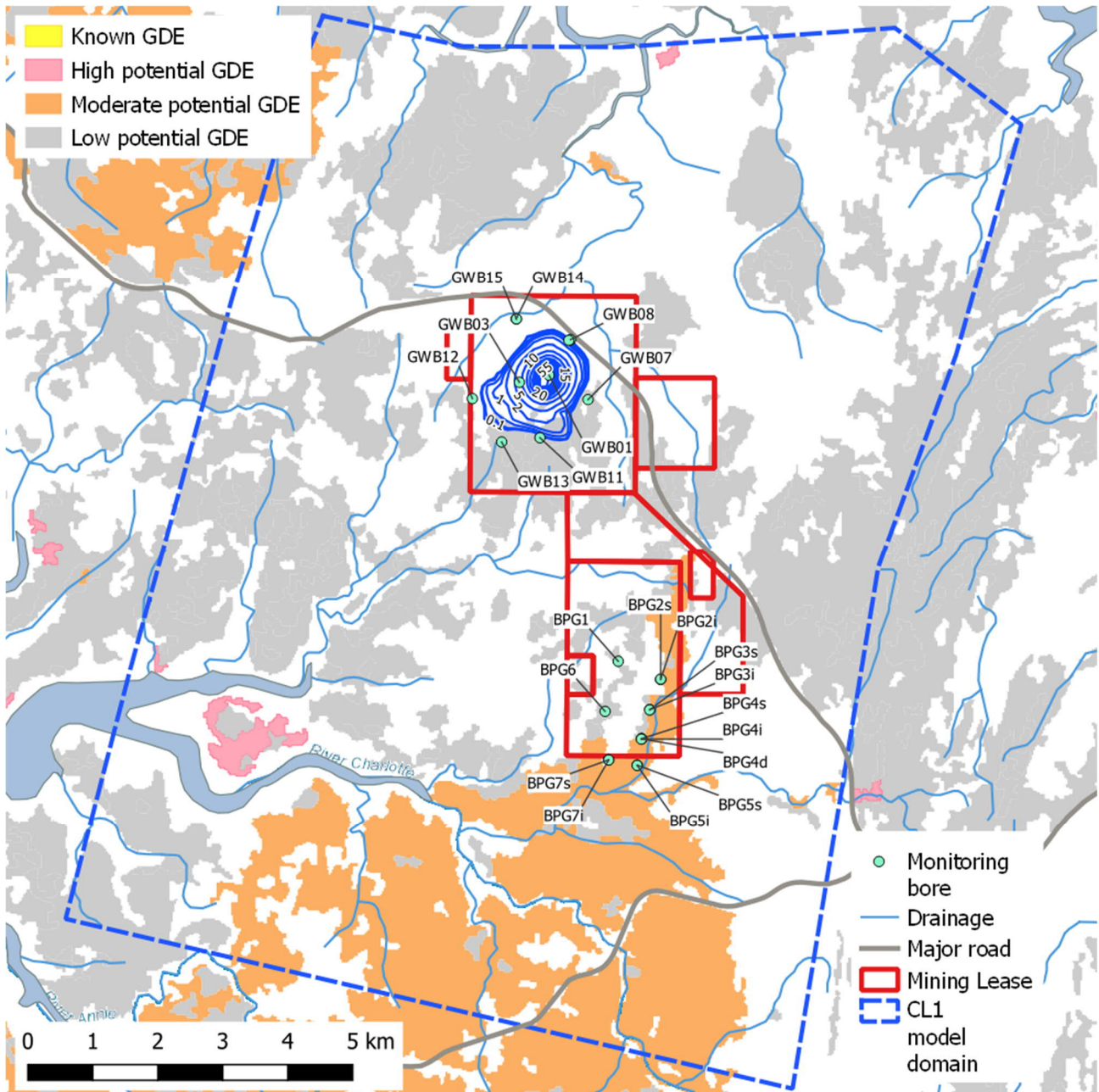


Figure 6-18 Post closure drawdown contours after 3 years of recovery (month 92).

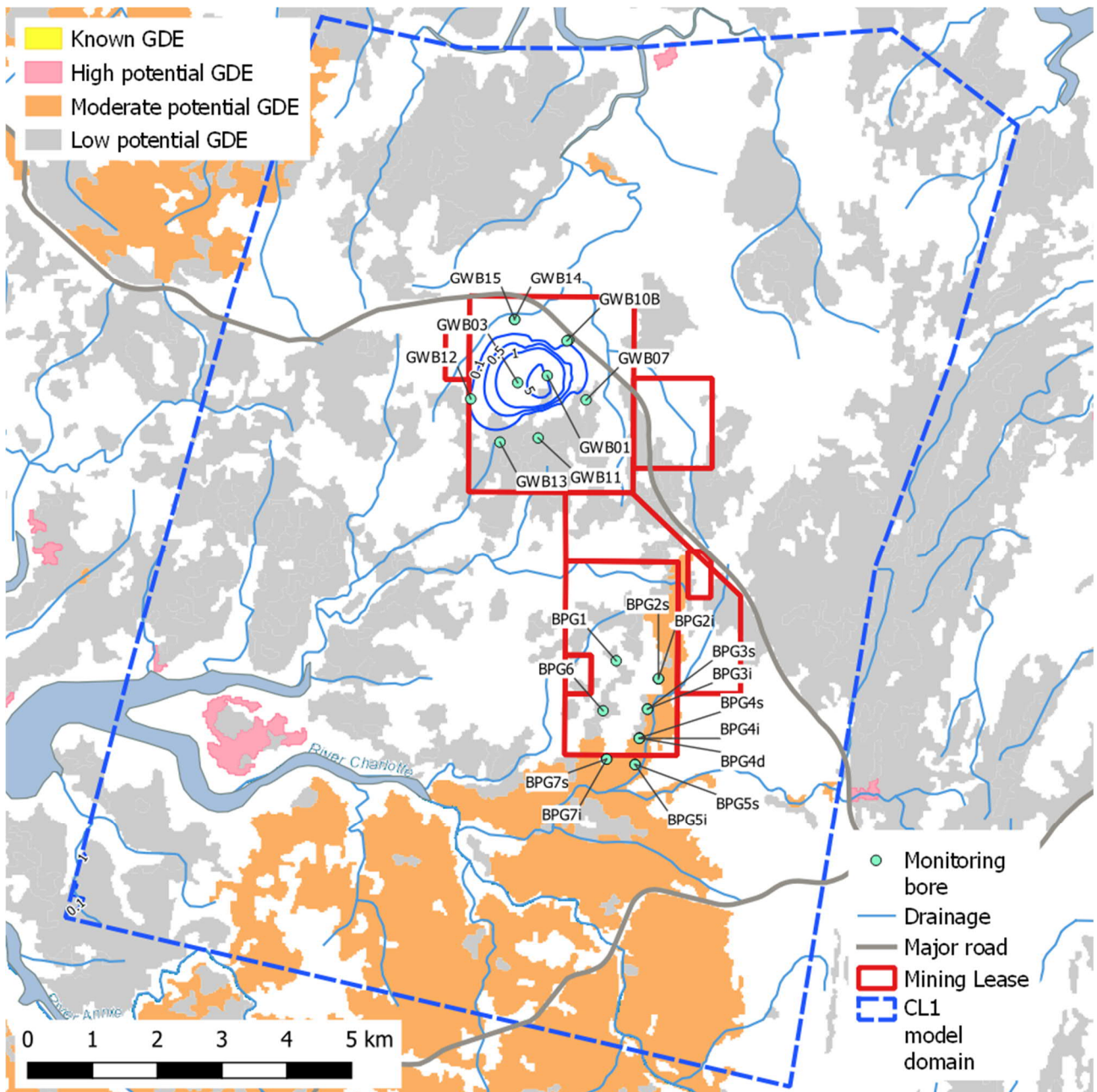


Figure 6-19 Post closure final drawdown contours after 70 years of recovery.

6.4. Particle tracking from the BP33 WRD

Forward particle tracks or streamlines can simulate the advective transport of solutes and are determined by releasing a number of particles from seeding points (in this case the nodes beneath the box-cut waste rock dump), into the groundwater flow field. The particles move along the hydraulic gradient (downgradient) until exiting the model at an outflowing boundary (or ending up in a zone without significant flow velocity). In this way forward particle tracks help visualize groundwater flow and can be used to determine the fate of solutes leaching into the groundwater system. Backward particle tracking can be used to delineate areas of contribution and capture zones. The use of streamlines assumes steady-state flow conditions.

Random-Walk Particle-Tracking (RWPT) solutions can be obtained by incorporating dispersive processes to the standard advective particle tracking. RWPT solutions are theoretically consistent with advection - dispersion equation solutions.

Table 6-2 Random walk particle tracking dispersive parameters.

PARAMETER	VALUE	UNIT
Effective porosity	0.02	[-]
Longitudinal dispersivity	10	[1/m]
Transverse dispersivity	1	[1/m]

6.4.1. EoM particle tracking

The fate of particles seeded beneath the box-cut waste rock dump (WRD) at the end of mining (EoM) at month 60 are presented below in Figure 6-20.

The majority of particles terminate at the decline and underground mine to the east of the WRD as the groundwater gradient is towards these features. A small proportion of particles beneath the western portion of the WRD are not captured and terminate to the west of the proposed mine footprint.

Note that the analysis assumes that no additional recharge (associated with leakage from the waste rock) is assigned within the footprint of the WRD. Including additional recharge may result in a mound developing beneath the WRD and a greater proportion of the particles terminating to the west.

Model Results

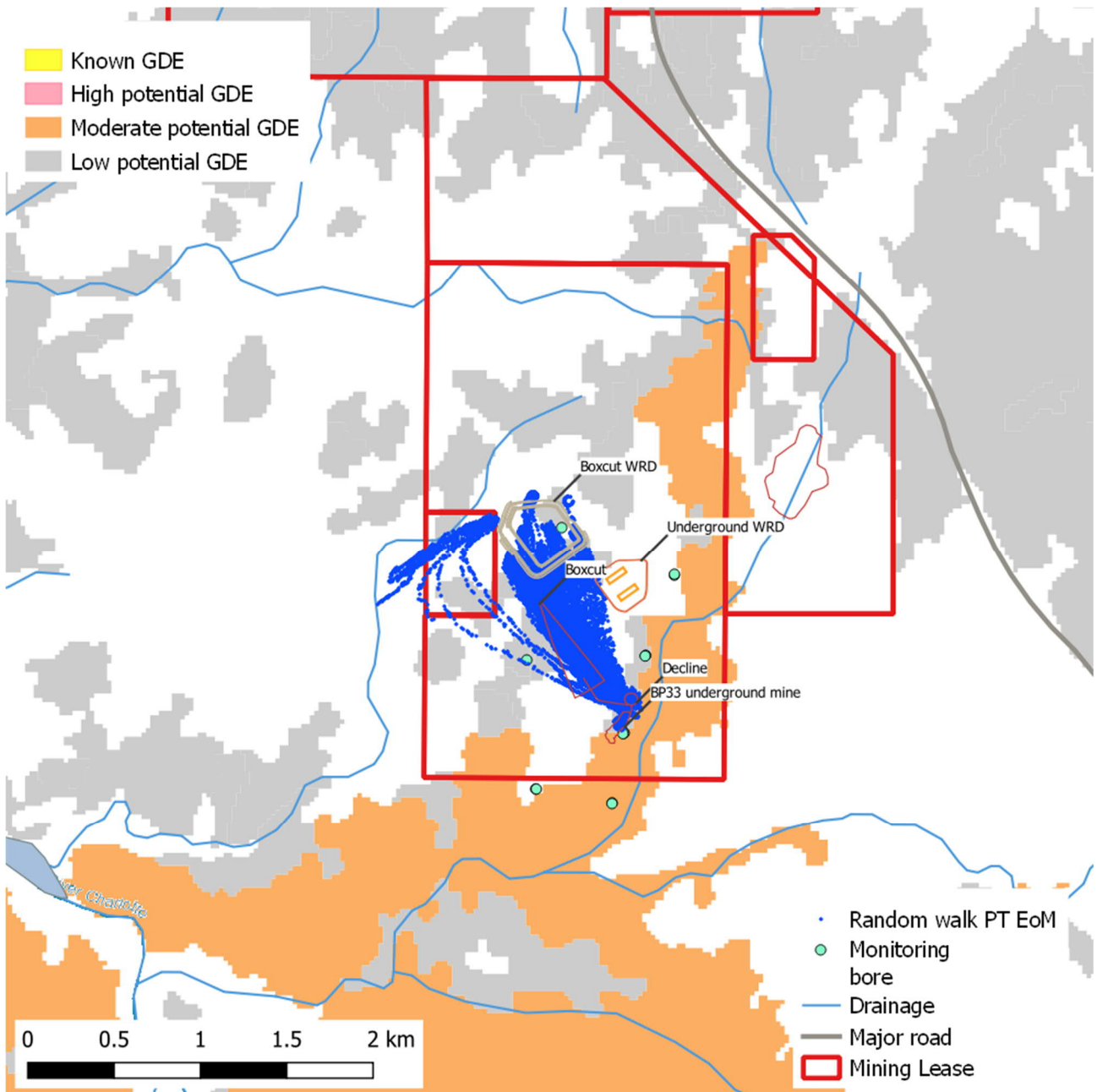


Figure 6-20 Random walk particle tracking at the EoM (month 60).

6.4.2. Post closure particle tracking

Random walk particle tracking has also been used to investigate the fate of particles beneath the proposed box-cut waste rock dump following closure of the mine (Figure 6-21). The parameters used to calculate the particle tracks are consistent with those used to determine particle tracking for EoM.

The particle tracks are different to those determined for the EoM with the particles distributed roughly evenly to the east and west of the box-cut WRD. The recovery of groundwater within the box-cut and underground workings has resulted in the return of the natural gradient towards the drainage lines to the east and west.

Model Results

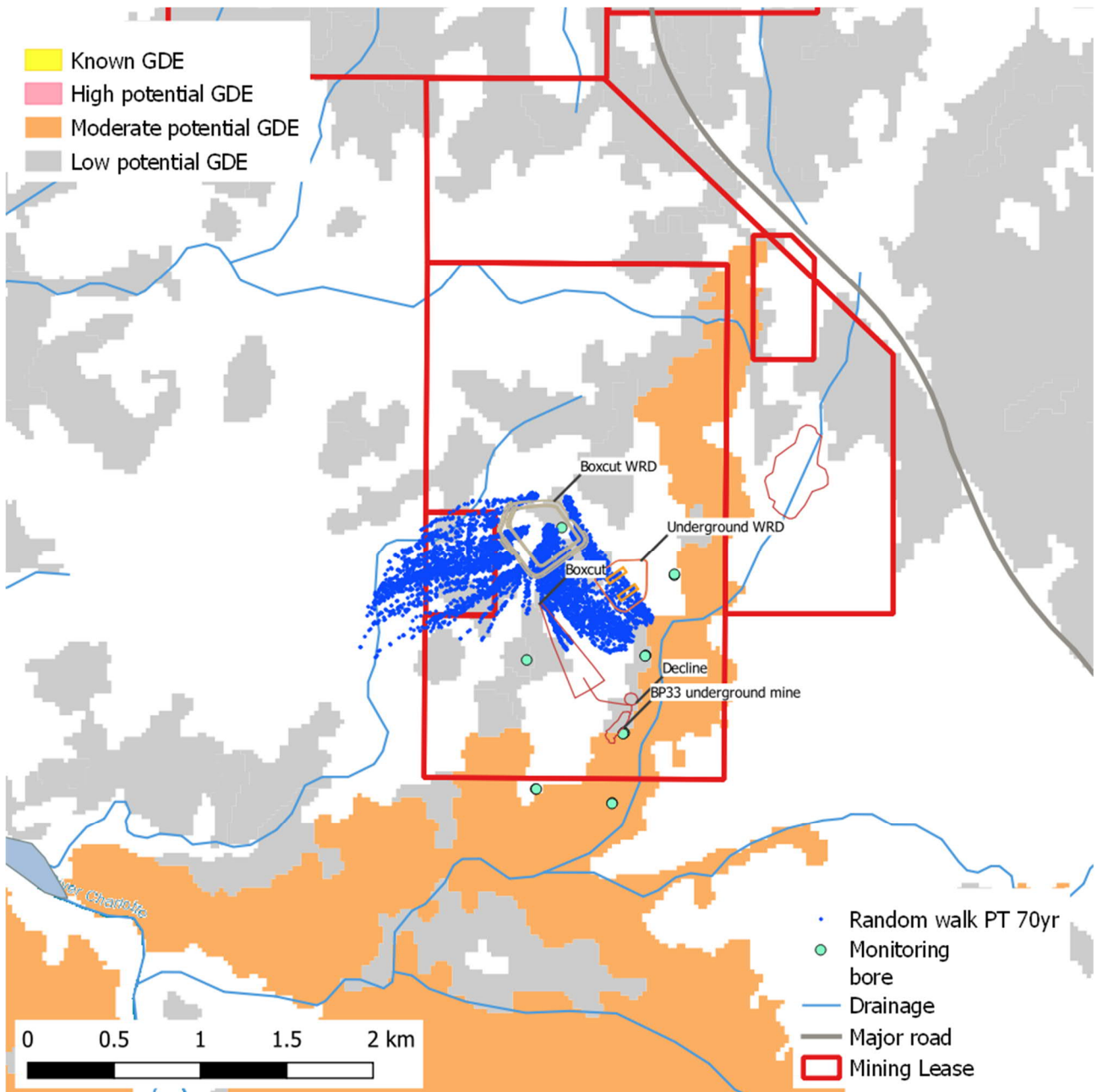


Figure 6-21 Post closure random walk particle tracking from the box-cut waste rock dump after 70 years recovery.

7 Conclusions

A numerical model was developed to assess the cumulative groundwater impacts resulting from the proposed development of an open cut lithium mine (Grants Lithium Project) and a nearby underground lithium mine (BP33) situated on MLA31726, MLA32074 and MLA32346, approximately 33 km west of Berry Springs. The mines are proposed to run for a total of 60 months. Proposed mine closure at BP33 will see the underground mine left as a mine void with the overlying box-cut filled with waste rock. At the GLP the pit void will be left to form a pit lake post closure.

A numerical groundwater model was developed using the FEFLOW modelling code and was underpinned by a conceptual groundwater model. Model parameter estimation was undertaken in accordance with best practice guidelines (Barnett et al, 2012). The model is deemed to meet the requirements of a Class 2 model and is suitable for providing estimates of dewatering requirements for mines and the associated impacts.

Predictive scenarios were run to determine mine inflows during the life of the mine (60 months), to estimate the cumulative impacts from GLP/BP33 on the watertable and to simulate the recovery of groundwater levels post closure (70 years).

7.1. Life of Mine Forecasts

Numerical model scenarios were run to assess groundwater impacts and pit inflows over the 60 month mining period. At the end of mining dewatering from the base of the GLP pit and dewatering of the box-cut, decline and underground mine at BP33 will result in the development of two separate drawdown cones in the surrounding aquifer. The predicted drawdown cone extends approximately 1 km from the GLP pit and around 2 km from the BP33 underground mine.

The drawdown cone in the vicinity of the GLP pit is not predicted to affect groundwater levels beneath ephemeral drainage lines or impact water levels outside the mining lease. The drawdown cone in the vicinity of the BP33 underground mine is predicted to affect groundwater levels beneath ephemeral drainage lines and also extend outside the mining lease.

The drawdown cone at the end of mining at BP33, shows the 0.1 m contour extending approximately 1 km beyond the western, southern and eastern boundary of the ML and intersecting ephemeral drainage lines to the west and east of the ML. The drawdown cone is predicted to extend beneath areas in the east and south of the ML that are mapped as having moderate GDE potential.

Groundwater inflow into the underground mine at BP33 is expected to peak at around 6000 – 7000 kL/day (69 – 80 L/s) for the life of the mine.

7.2. Post Closure Forecasts

Based on the groundwater modelling results, it is very unlikely that the drawdown impacts predicted at Grants and BP33 will interact.

The post closure model scenario predicts that groundwater levels at BP33 will recover to pre-mining levels within 3 years of the closure of the mine. This assumes that the underground mine and decline are left as mining voids and the box-cut is backfilled with material that has storage properties a magnitude higher than the in-situ host rock. The modelling suggests that

Conclusions

any impacts to GDEs are likely to be short-term and persist for a period of approximately 5 years.

Consistent with previous modelling (CloudGMS, 2018) the post closure model scenario predicts that the GLP pit lake will fill slowly over a period of roughly 50 years before the water level stabilises at 12 – 13 mASL or around 7 - 8 m below the existing land surface.

8 References

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