Jimblebar Hub: Groundwater Impact Assessment

December 2023
Version 1.0

Authorisation

Version	Description of Version	Position	Date
0	Initial version for Traditional Owner information	Superintendent, Water Stewardship & Approvals (Water Planning)	29 October 2023
1.0	Final as part of Jimblebar Hub Significant Amendment referral to EPA	Superintendent, Jimblebar Hydrogeology	06 December 2023

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1 Purpose

The purpose of this document is to provide an assessment of the impacts on groundwater water resources from the proposed increased groundwater abstraction for mine dewatering from the Jimblebar mine to support the Jimblebar Hub Iron Ore Mining Operations Significant Amendment (Jimblebar Hub Proposal) (BHP 2023a).

The *Jimblebar Hub: Ophthalmia Dam surplus water impact assessment update* (BHP 2023b) documents the assessment of the impacts of discharge of surplus mine dewater from BHP's Eastern Pilbara mines to Ophthalmia Dam (including the contribution from the Jimblebar Hub).

2 Scope

The Jimblebar Hub Proposal includes a new mine area (East Jimblebar deposit) and increased abstraction (for dewatering) of approved deposits at the existing Jimblebar mine and dewatering of the East Jimblebar deposit. No changes are proposed to the approved groundwater abstraction (including dewatering) rates for the other existing mines in the Jimblebar Hub (Orebody 31 and Orebody 18). BHP has undertaken the *Jimblebar Hydrogeological Assessment (140 ML/d)* (Appendix A; BHP 2023c) to assess the potential impacts from the current (2023) long-term mine (and dewatering) plan at the Jimblebar mine, to support *Rights in Water and Irrigation 1914* (RiWI) 5C licence and *Environmental Protection Act 1986* (EP Act) Part IV approval processes.

However, as the Jimblebar Hub Proposal is a significant amendment (BHP 2023a) to Approved Proposals under Part IV of the EP Act in the Jimblebar Hub (the existing Jimblebar, Orebody 31 and Orebody 18 mines), BHP has provided information in this document on the previous assessments of groundwater abstraction for the existing mines and the combined effects that the Approved Proposals and the Jimblebar Hub Proposal might have on the environment.

The key previous assessments for the Approved Proposals are:

- *Hydrogeological Assessment for Jimblebar Iron Ore Project* (Aquaterra 2009); Appendix G to *Jimblebar Iron Ore Project Environmental Protection Statement* (BHP Billiton 2010)
- *Jimblebar Detailed Hydrogeological Assessment* (BHP Billiton 2017)
- *Jimblebar Detailed Hydrogeological Assessment – 72ML/d* (BHP 2021)
- *Orebody 31 Hydrogeological Impact Assessment: Summary Document* (BHP Billiton 2015a); Appendix I to *Orebody 31 Iron Ore Mine Project Environmental Referral Document* (BHP Billiton 2015b).

3 Existing environment and environmental values

BHP's Jimblebar Hub comprises existing mining operations at the Jimblebar, Orebody 31 and Orebody 18 mines, and is located approximately 40 km east of the town of Newman (Figure 1). Mining operations commenced at the Jimblebar Hub over thirty years ago. There are three current Approved Proposals (existing projects) for the Jimblebar Hub operations:

- Jimblebar Iron Ore Project (Revised Proposal): Ministerial Statement (MS)1126
- Orebody 31 Iron Ore Project: MS1021
- Orebody 18 Iron Ore Mine: MS439 (as amended by MS1012).

The approved Orebody 18 mine comprises the Orebody 17 and Orebody 18 deposits. When referring to the approval title under Part IV, BHP refers to Orebody 18. When discussing the mine and/or deposits, BHP refers to Orebody 17/18 (OB17/18). BHP also refers to the Orebody 18 and Orebody 31 mines collectively as the Shovelanna area.

The groundwater regime has been altered by groundwater abstraction for water supply and for dewatering orebodies to access below water table ore. Groundwater abstraction for water supply commenced at Jimblebar in 1994. Groundwater abstraction for mine dewatering activities commenced at Jimblebar in 2011 and Shovelanna (OB17/18 and OB31) in 2015. Mining and dewatering is active at the Jimblebar and Orebody 31 mines. Dewatering at OB17/18 has ceased. BHP also injects surplus groundwater in the Orebody 18 (Ninga) managed aquifer recharge (MAR) and Caramulla MAR scheme areas.

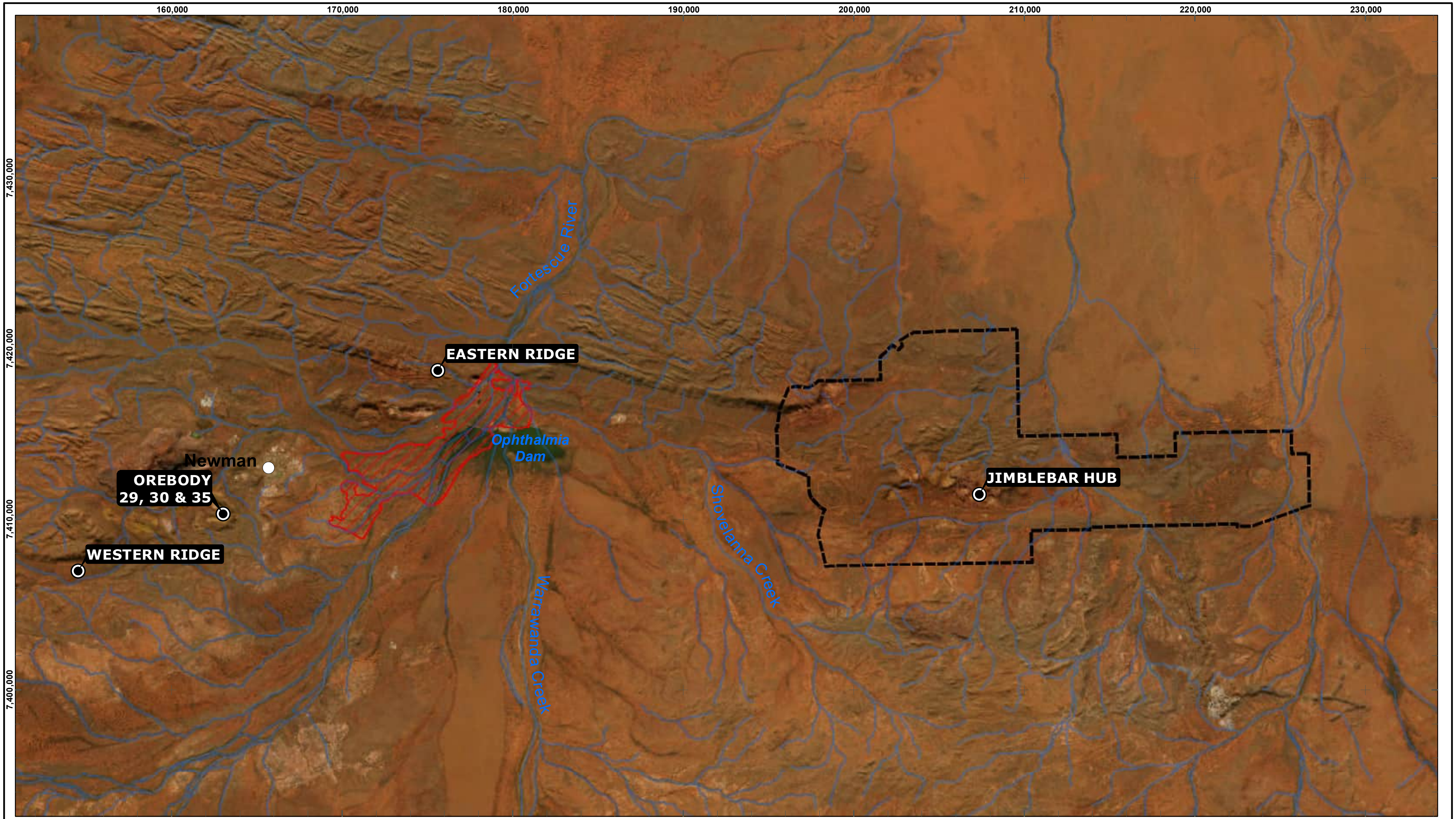
The Ophthalmia Dam system, located approximately 20 km from the Jimblebar Hub, partially overlies the Ethel Gorge aquifer which supports the Ethel Gorge aquifer stygobiont community Threatened Ecological Community (Ethel Gorge TEC). Ophthalmia Dam was commissioned in 1981 as a MAR scheme, to maintain groundwater levels within the Ethel Gorge aquifer and to support the Ophthalmia Borefield, which BHP has operated since the 1970s. The Ophthalmia Dam system continues to maintain groundwater levels within the Ethel Gorge aquifer to protect the Ethel Gorge TEC habitat and also provides a discharge location for surplus water from BHP mines in the Eastern Pilbara area (currently Eastern Ridge, Orebody 29/30/35, Jimblebar and Orebody 31) (BHP 2023b).

The main water-related environmental values that potentially may be impacted by groundwater abstraction from the Jimblebar Hub are (Figure 1):

- local groundwater resource in the Jimblebar Hub area
- Ethel Gorge aquifer (and TEC).

The hydrogeological assessment for the current (2023) Jimblebar long-term mine plan (BHP 2023c) identifies other groundwater users. Most of the nearby users are other BHP operations. Other third party users have been identified but are unlikely to be impacted by abstraction from the Jimblebar mine. BHP will provide a monitoring strategy as part of the *Rights in Water and Irrigation Act 1914* (RiWI Act) s5C Licence to Take Water Groundwater Operating Strategy if any third party groundwater users may negatively impacted (BHP 2023c).

The Fortescue Marsh is located approximately 120 km north (downstream) of Ophthalmia Dam along the Fortescue River at the terminus of the Upper Fortescue River. The aquifer system underlying Fortescue Marsh is not connected to the Jimblebar Hub orebody aquifers and will not be impacted by groundwater abstraction (including for dewatering) at the Jimblebar Hub.



Proposed Development Envelope
BHP mine
Watercourse
Ethel Gorge TEC

N
0 5 10
KILOMETRES
GDA 1994 MGA ZONE 51

BHP

PUBLIC

GROUNDWATER
ENVIRONMENTAL IMPACT ASSESSMENT
Regional context

PLANNING & STANDARDS - IRON ORE

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4 Hydrogeology

Regional aquifers are located through the central valleys of the Jimblebar Hub area (vicinity of the proposed Development Envelope shown in Figure 2) and are made up of:

- weathered Paraburdoo (and Bee Gorge) Members of the Wittenoom Formation; the Paraburdoo dolomite in particular can be karstic and highly permeable
- sand and gravel occurrences in the Tertiary Detritals; the detritals are very thick in places, ranging from 200 to 360 m thick.

At the local scale, orebody aquifers in the Jimblebar Hub are made up of mineralised and submineralised material:

- The Marra Mamba Formation forms an almost continuous east/west striking aquifer in the south, with some orebodies reaching depths of approximately 110 m below water table (BWT). The Marra Mamba Formation hosts the South Jimblebar deposits at the Jimblebar mine.
- The Brockman Iron Formation, which also forms almost continuous east/west striking aquifers in the north; whilst these aquifers are discontinuous, they can be very large, reaching depths of approximately 110 m to 140 m BWT. The Brockman Iron Formation hosts the OB17/18 and OB31 in the Shovelanna mine area, and the Wheelarra Hill, Hashimoto and East Jimblebar deposits at the Jimblebar mine (BHP 2023c).

Figure 2 shows the hydrogeological conceptualisation in the Jimblebar Hub area during operations (i.e. with groundwater abstraction and injection activities). There is no hydraulic connection between the Jimblebar mine area and the Shovelanna mine area (OB31 and OB17/18) due to the presence of the Wheelarra Fault.

4.1 Jimblebar mine area conceptualisation

Regional and local geological structures act as groundwater flow barriers. There is little or no groundwater flow across the Wheelarra Fault in the west and the northeast-southwest trending structures (including the Khyber Fault) in the east (Figure 2). Locally there are several structures that, as shown by the propagation of drawdown, provide either partial or complete barriers to groundwater flow. These include the Central, Comedy and Monster faults (Figure 2). Groundwater flow is inferred to be generally from the south to the north. To the west of the Central Fault, dewatering activities (especially dewatering at the South Jimblebar deposits) result in groundwater flow towards the South Jimblebar deposit, and a southerly flow component across much of western part of the Jimblebar operations.

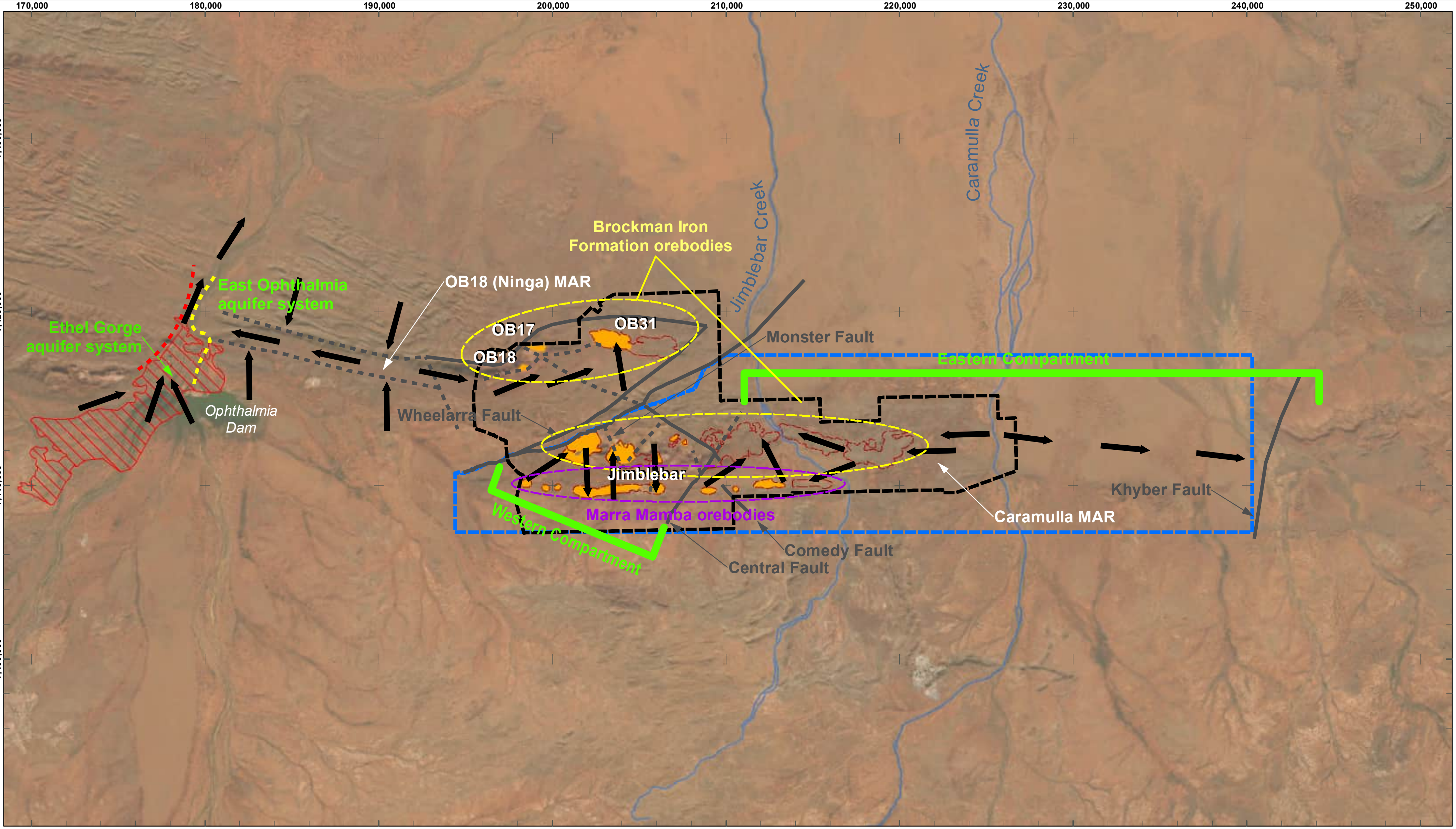
4.2 Shovelanna mine area conceptualisation

Current groundwater flow is generally from the west to east in the regional aquifer and then north into OB31, with localised radial flow towards OB18 and OB31, where dewatering activities occur (Figure 2). There is a hydraulic barrier (likely a dyke) through the weathered Wittenoom regional aquifer (and probably orebody aquifers) between OB18 and OB17. OB17 and OB31 are hydraulically connected, likely through the Brockman orebody. Since the Orebody 18 mine was approved under Part IV of the EP Act, BHP now refers to the portion of the OB18 mine originally referred to as the OB18 North pit as the OB17 Swan pit. This is consistent with the hydrogeological conceptualisation that OB18 is not hydraulically connected to OB17.

4.3 Regional conceptualisation from Jimblebar Hub to Ethel Gorge area

The regional aquifer (made up of weathered Wittenoom Formation and Tertiary Detritals) is continuous from the east (OB31) to the west (Ethel Gorge). However, there are at least two partial groundwater flow barriers (probably dykes) along this flow path (Figure 2). These form three distinct aquifer compartments between OB31 and the Ethel Gorge aquifer. The OB17 and OB31 deposits are within the orebody aquifer compartment furthest from the Ethel Gorge aquifer, a compartment defined by flow barriers on all sides. Pre-development, it was likely that there was only low groundwater flow from the OB17 and OB31 orebody aquifer compartment from east to west across the dyke towards the Ethel Gorge aquifer (20 km to the west of the Jimblebar Hub). With dewatering of OB31 and operation of the Orebody 18 (Ninga) MAR, the flow direction has reversed (ie is from west to east) up to roughly the area of the Orebody 18 (Ninga) MAR.

There is no hydraulic connection from the Jimblebar orebody aquifers to the Ethel Gorge aquifer, due to the presence of the Wheelarra Fault.



Proposed Development Envelope
Flow barrier
Partial flow barrier
Model domain
Ethel Gorge TEC
Existing pits
Proposed pits
Groundwater flow

N

0 5 10

KILOMETRES

GDA 1994 MGA ZONE 51

BHP

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GROUNDWATER
ENVIRONMENTAL IMPACT ASSESSMENT
Conceptual groundwater system

PLANNING & STANDARDS - IRON ORE

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5 Historical and current groundwater levels

5.1 Jimblebar mine area groundwater levels

Pre-development (pre-abstraction) groundwater levels were relatively flat in the Jimblebar area (approximately 462 mRL), particularly in the areas of the orebody and regional aquifers. Pre-development groundwater levels in the Jimblebar mine area were deep, generally greater than 50 m below ground level (mbgl) in the eastern end of the proposed Development Envelope to greater than 100 mbgl in the western end of the proposed Development Envelope (Figure 3 and Figure 4).

Since dewatering commenced at the Jimblebar mine in 2011, observed groundwater drawdown in the Jimblebar area is greater than 40 m in the west between the Wheelarra and Central faults and decreases to the east (Figure 4). The observed drawdown in 2021 of approximately 1.5 m in the east near Caramulla Creek (BHP 2023c) has decreased since the implementation of the Caramulla MAR scheme in 2022. Current groundwater levels in the Jimblebar area range between approximately 175 mbgl in the west to 50 mbgl in the east near Caramulla Creek.

Streamflow systems in the vicinity of the Jimblebar orebody aquifers are likely to be in poor hydraulic connection with groundwater systems due to groundwater levels being at least 50 m below the surface, and recharge responses are only observed after significant rainfall and runoff events. Therefore, it is not expected that these aquifers support near surface, groundwater dependent ecosystems, such as vegetation or surface water pools (BHP 2023c).

5.2 Shovelanna mine area groundwater levels

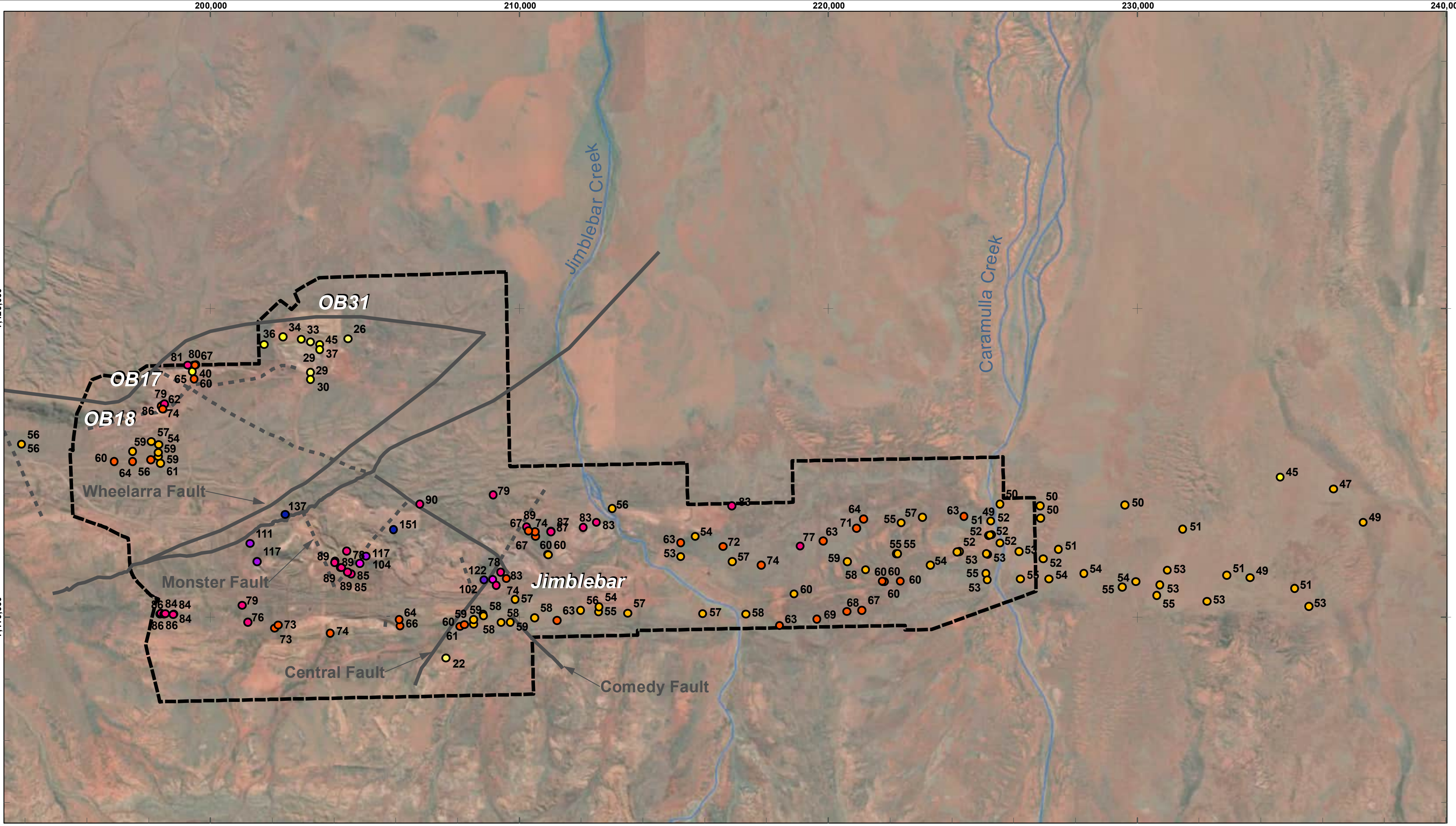
Pre-development groundwater levels in the Shovelanna mine area (approximately 500 mRL) were shallower than in the Jimblebar mine area, generally 30 mbgl in the vicinity of OB31 to greater than 40 mbgl at OB18 (Figure 3 and Figure 4).

The difference in the pre-development groundwater levels in the Jimblebar and Shovelanna areas supports the hydrogeological conceptualisation (discussed in Section 4) that there is very little hydraulic connection between the Jimblebar and the Shovelanna mine areas due to the presence of the Wheelarra Fault.

Since dewatering commenced in the Shovelanna mine area in 2015, observed groundwater drawdown is up to 35 m at OB18 and greater than 60 m at OB17 and OB31 (Figure 4). Current groundwater levels range from approximately 50 to 95 mbgl at OB31 and greater than 100 mbgl at OB17/18.

5.3 Ethel Gorge area groundwater levels

Figure 5 presents observed groundwater levels in the Ethel Gorge area since the early 1970s when monitoring began. The data shows that while there is variability in the groundwater levels in Ethel Gorge East bores (in the East Ophthalmia Aquifer System shown in Figure 2) and the Ethel Gorge North bores (in the Ethel Gorge Aquifer System shown in Figure 2), the groundwater levels do not show any response to the groundwater abstraction in the Shovelanna area. Furthermore, during dewatering of OB31 it is very unlikely that there will be any groundwater flow towards the east from the Ethel Gorge aquifer across the dykes towards the OB17 and OB31 orebody aquifer compartment. This is due to the presence of the dykes, but also the operation of Orebody 18 (Ninga) MAR (which takes some surplus water from OB31), located between the Shovelanna area and the Ethel Gorge aquifer. While the Orebody 18 (Ninga) MAR is operational, a groundwater divide is likely to exist close to the MAR borefield, with groundwater flowing towards the Ethel Gorge aquifer to the west of the MAR and towards Shovelanna to the east of the MAR (Figure 2).



Proposed Development Envelope
Flow barrier
Partial flow barrier

Pre-development groundwater level (mbgl)

- 16 - 30
- 31 - 45
- 46 - 60
- 61- 75
- 76 - 90
- 91 - 105
- 106 - 120
- 121 - 135
- 135 - 150

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BHP

PUBLIC

GROUNDWATER
ENVIRONMENTAL IMPACT ASSESSMENT
Pre-development groundwater levels

PLANNING & STANDARDS - IRON ORE

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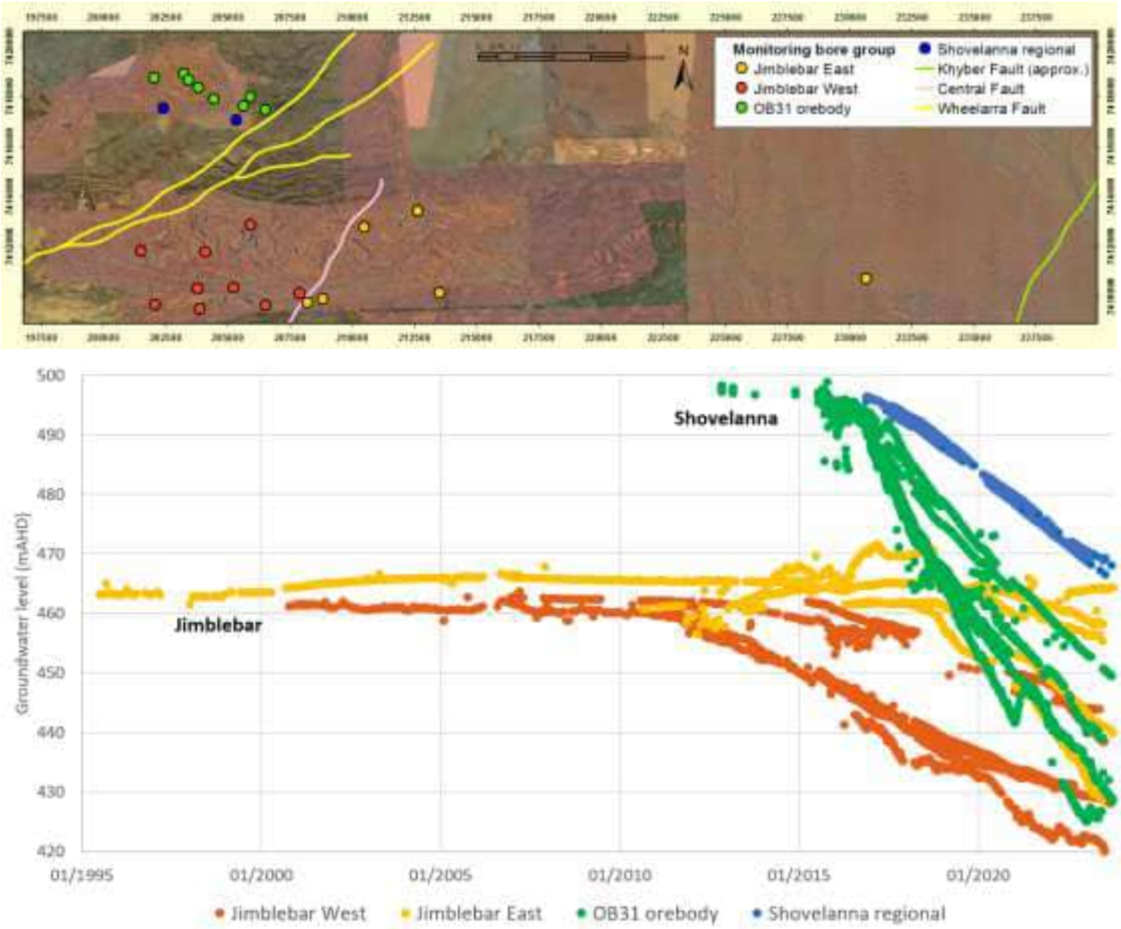


Figure 4: Observed groundwater levels in the Jimblebar and Shovelanna areas

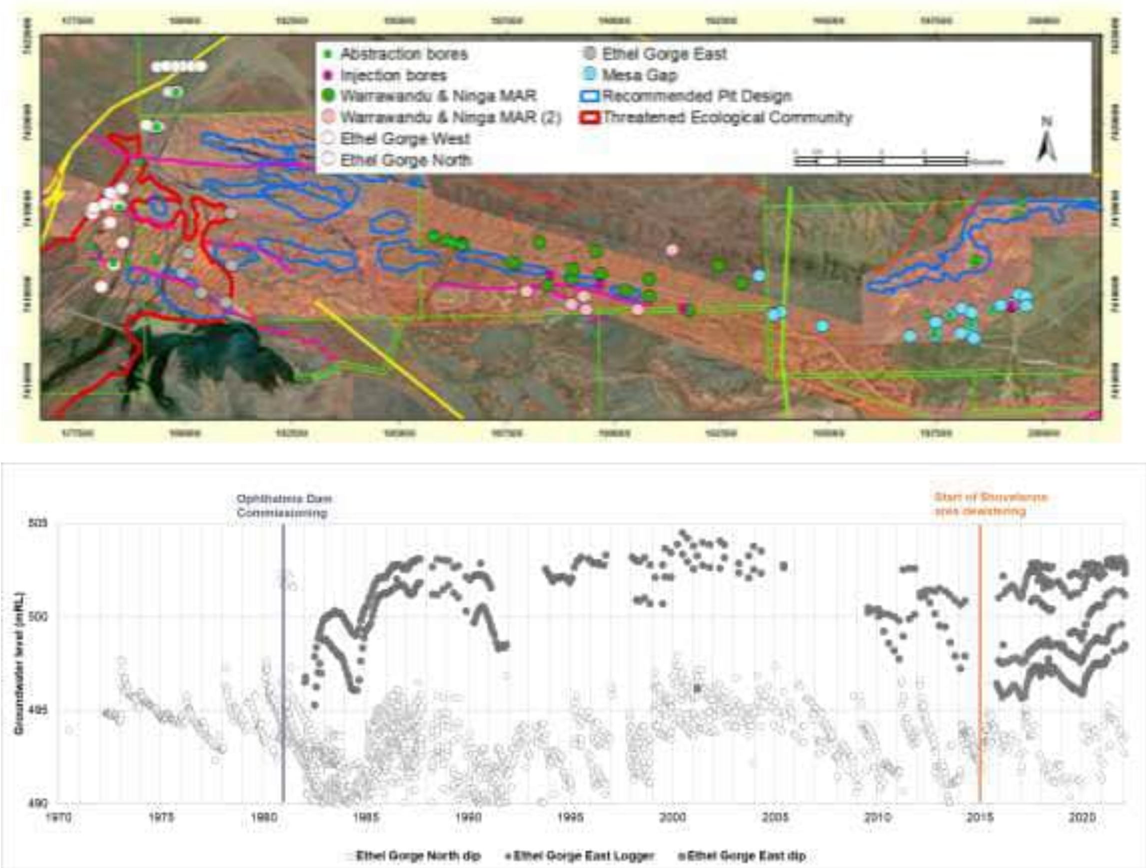


Figure 5: Observed groundwater levels in the Ethel Gorge area

6 2023 Jimblebar mine groundwater modelling

As discussed in Section 2, the Jimblebar Hub Proposal includes changes to dewatering at the Jimblebar mine only. Therefore, this section discusses the current (2023) groundwater modelling for the Jimblebar mine only.

The numerical model used to predict the impacts of the current (2023) long-term mine (and dewatering) plan at the Jimblebar mine is described in the *Jimblebar Hydrogeological Assessment* (Appendix A; BHP 2023c). The model domain (Figure 2)Figure 8 extends from the Wheelarra Fault in the west to the vicinity of the Khyber Fault in the east.

The groundwater model includes dewatering from the Jimblebar orebodies which have already been approved for dewatering (Wheelarra Hill, South Jimblebar and Hashimoto deposits) and dewatering from the proposed East Jimblebar deposit.

6.1 Sensitivity analysis and predictive confidence

A sensitivity analysis was undertaken with the calibrated model (the base case) to determine whether model outputs were sensitive to changes in key aquifer parameter values (specific yield and hydraulic conductivity) and whether the changes in key parameter values should be considered in the predictive uncertainty analysis (i.e. dewatering predictions). Runs were undertaken for a range of parameters. The analysis showed that the simulated groundwater level response is moderately sensitive to all of the model parameters tested. Parameter values that produced negative changes to the model performance (reductions in goodness of fit of observed and simulated data) were not considered in the predictive uncertainty (BHP 2023c).

Confidence in the ability of the model to predict the response to future dewatering varies throughout the model domain. In the compartment to the west of the Central Fault (Western Aquifer Compartment), which includes the Wheelarra 123 and South Jimblebar (Mindoona and Sylvania) deposits, there is a high level of confidence. In the area east of the Central Fault (Western Aquifer Compartment) which includes the approved Hashimoto, South Jimblebar (Capricorn) deposits and the proposed East Jimblebar deposit, there is moderate to low confidence. To the north of the Brockman orebodies predictive confidence is low. The area is vast, and the monitoring is limited to a few bores. To the south of the Marra Mamba orebodies predictive confidence is moderate to high. The area is also vast but the monitoring bores provide consistent responses to dewatering (BHP 2023c).

6.2 Predicted groundwater abstraction rates and drawdown

The predictive version of the model was run for 30 years from Financial Year (FY) 2022 to FY2052 to assess the impacts of dewatering, specifically to:

- predict the likely dewatering rates required to achieve the Jimblebar target groundwater levels (Figure 6) (lowering groundwater levels by a maximum 150 m from pre-development groundwater levels to dewater the Jimblebar orebodies)
- predict the vertical and lateral extent of drawdown as a result of the dewatering.

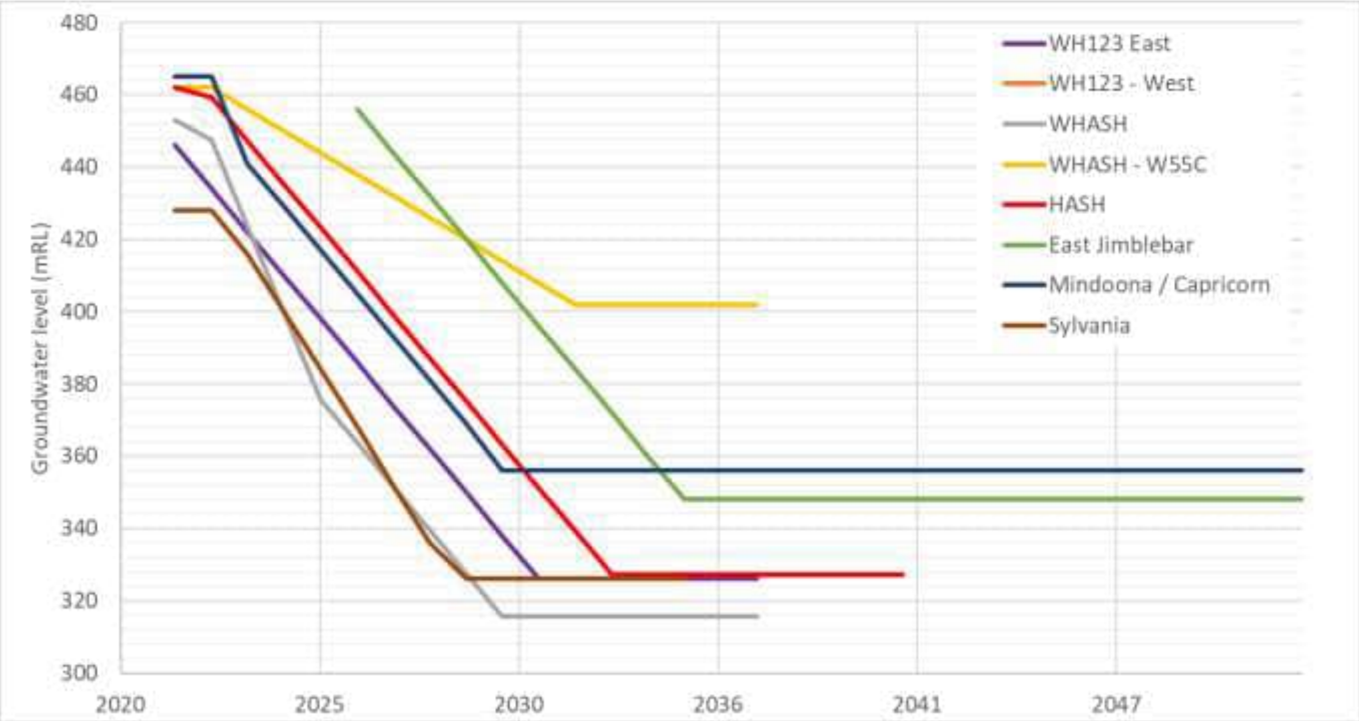


Figure 6: Target Jimblebar mine pit groundwater levels

Figure 7a shows the predicted dewatering rates for the four parameter runs used to show the magnitude of the range between the mid case (Base case) and high case (Run 19B) (originally run to 2044). The peak total dewatering rate for the Jimblebar mine (total for all deposits) ranges between 90.0 ML/d (Mid case) and 137.7 ML/d (High case). Figure 7b shows the drawdown extended to 2052 for the High case (Run 19B), as dewatering of the proposed East Jimblebar deposit and the approved Mindoona and Sylvania (South Jimblebar) deposits extends past 2044 (as shown in Figure 6).

Figure 7c shows the dewatering rates over time for each deposit for the High case (Run 19B). The results show that the predicted dewatering requirements are dominated by achieving the groundwater level targets for the approved Hashimoto (WHASH) and South Jimblebar (Sylvania) deposits and the predicted dewatering for the proposed East Jimblebar deposit is relatively low (peak of 8.1 ML/d).

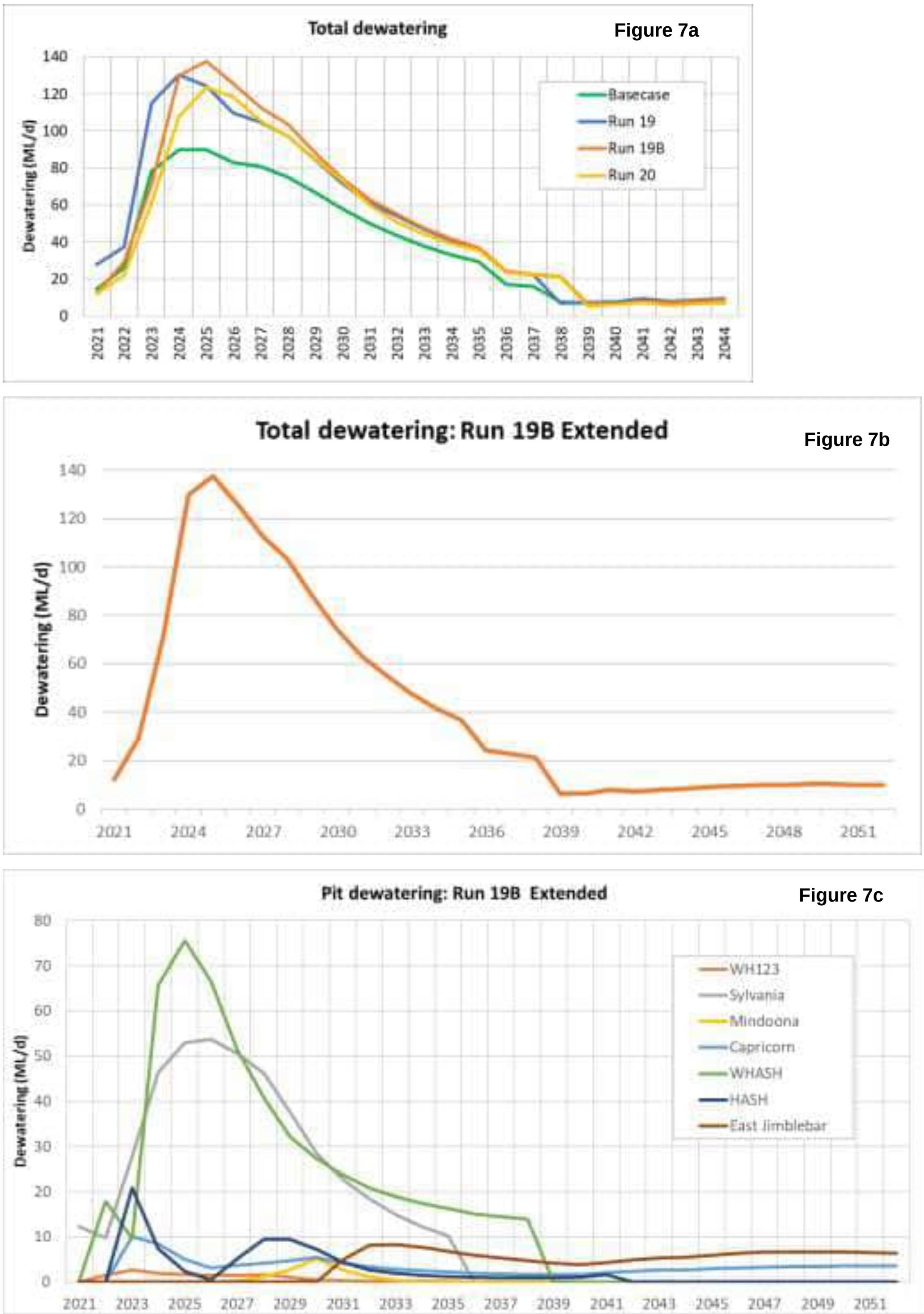
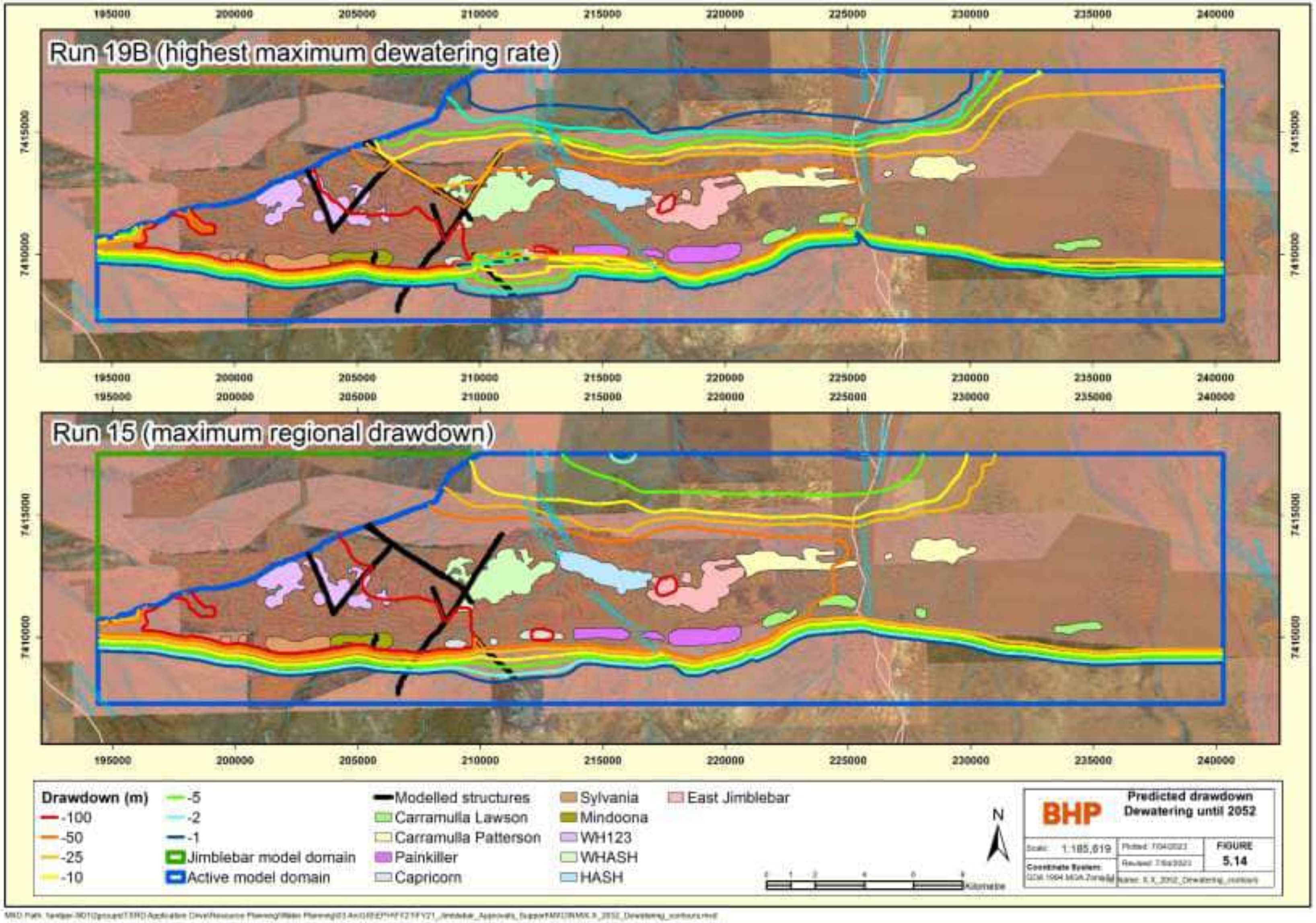


Figure 7: Predicted Jimblebar mine dewatering rates

As discussed above, BHP estimates that groundwater levels at Jimblebar would need to be lowered by up to approximately 150 m from pre-development groundwater levels (from approximately 460 mRL down to approximately 310 mRL as shown in Figure 6). Figure 8 shows the predicted drawdown at the end of the model simulation (FY2052) to achieve the target pit groundwater levels shown in Figure 6 for the runs that predict the highest dewatering rate (Run 19B) and the highest regional drawdown (Run 15 with greater hydraulic connectivity to the north). The predicted drawdown for the high regional drawdown case (Run 15) has the potential to extend further north but is generally similar in all other areas compared to the high dewatering case (Run 19B).

The groundwater model predicts that the dewatering will result in a maximum vertical drawdown of up to approximately 100 m at the north western boundary of the model domain (along the Wheelarra Fault), up to 25 m at the northern and eastern boundary, and less than 1 m at the southern boundary, compared to pre-development groundwater levels.

The high dewatering case run (Run 19B) was used to assess the influence of the Caramulla MAR scheme on model predictions. The influence of the Caramulla MAR increases the peak dewatering rate to approximately 145 ML/d and locally reduces the drawdown in the regional aquifer in the vicinity of the MAR area but does not change the extent of the drawdown footprint (BHP 2023c).



Source: BHP 2023c

Figure 8: Predicted Jimblebar mine drawdown at 2052

6.3 Post-mining groundwater level recovery

Post-mining (closure), recovery of groundwater levels within the Jimblebar catchment will be driven by rainfall recharge only. Simple calculations, based on predicted volume abstracted over the life of mine, the area over which rainfall recharge can occur and the rate at which recharge occurs, suggest that the time period for recovery could be between 500 and 3,000 years (BHP 2023c).

For a full backfill scenario (i.e. pits fully backfilled to above the pre-development groundwater level), groundwater levels will recover to pre-development levels. The recovery of post-mining groundwater levels at the Jimblebar mine for the void options was modelled for the following scenarios using the 2023 groundwater model:

- no-backfill: all pits left as open voids
- backfill of selected pits: to above the pre-mining groundwater level, nominally WH56/H1 (WHASH) and WH123 pits in the Wheelarra and Hashimoto deposits and all other pits left as open voids.

For the no-backfill scenario, groundwater levels are predicted to recover to about 340 mRL in the Western Aquifer Compartment and 360 mRL in the Eastern Aquifer Compartment (compared to 462 mRL pre-development groundwater level). For the scenario with the backfill of selected pits, groundwater levels are predicted to recover to about 340 mRL in the Western Aquifer Compartment and 370 to 380 mRL in the Eastern Aquifer Compartment (compared to 462 mRL pre-development groundwater level). The analysis therefore suggests that whether or not some of the pits are backfilled, water levels in any open voids will remain much lower than pre-development groundwater levels (assuming a low recharge environment which is conservative). Therefore, the pit voids would remain groundwater sinks (Figure 9).

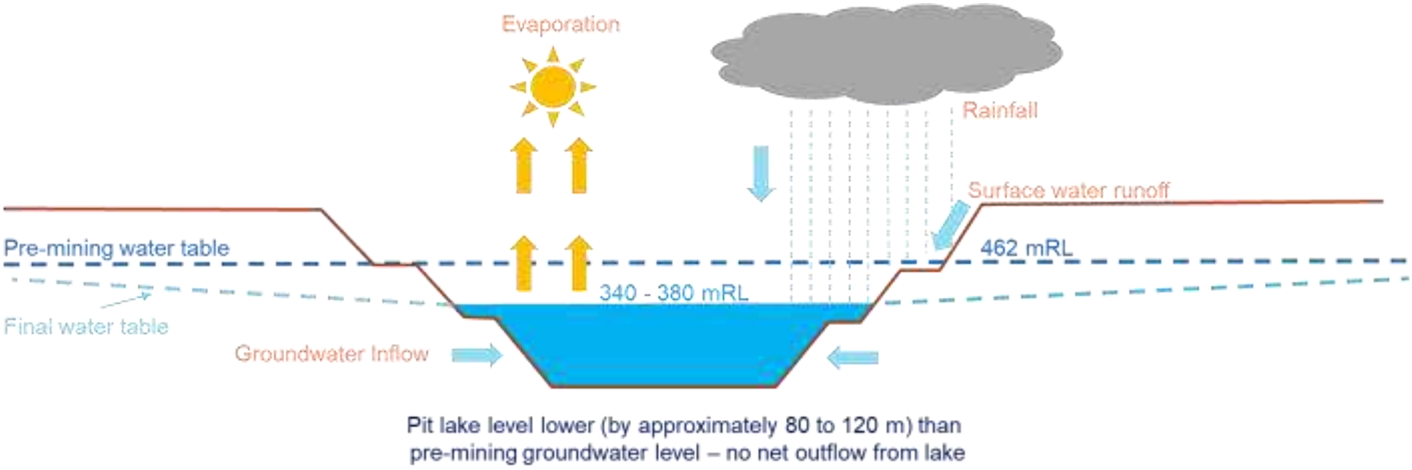


Figure 9: Conceptual pit lake diagram – sink

7 Groundwater abstraction and drawdown assessment

This section presents the assessment of groundwater abstraction and drawdown during operations for the following:

- Change in predicted groundwater abstraction and drawdown for the Jimblebar mine only (as there are no proposed changes to the approved dewatering rates for the Orebody 31 and Orebody 18 mines), compared to previously assessed groundwater abstraction and drawdown (Section 7.1). This forms part of the Jimblebar Hub Proposal.
- Combined effects of groundwater abstraction and drawdown for the predicted change for the Jimblebar mine and for the Approved Proposals in the Jimblebar Hub (the existing Jimblebar, Orebody 31 and Orebody 18 mines) (Section 7.2).

7.1 Change in Jimblebar mine groundwater abstraction and drawdown

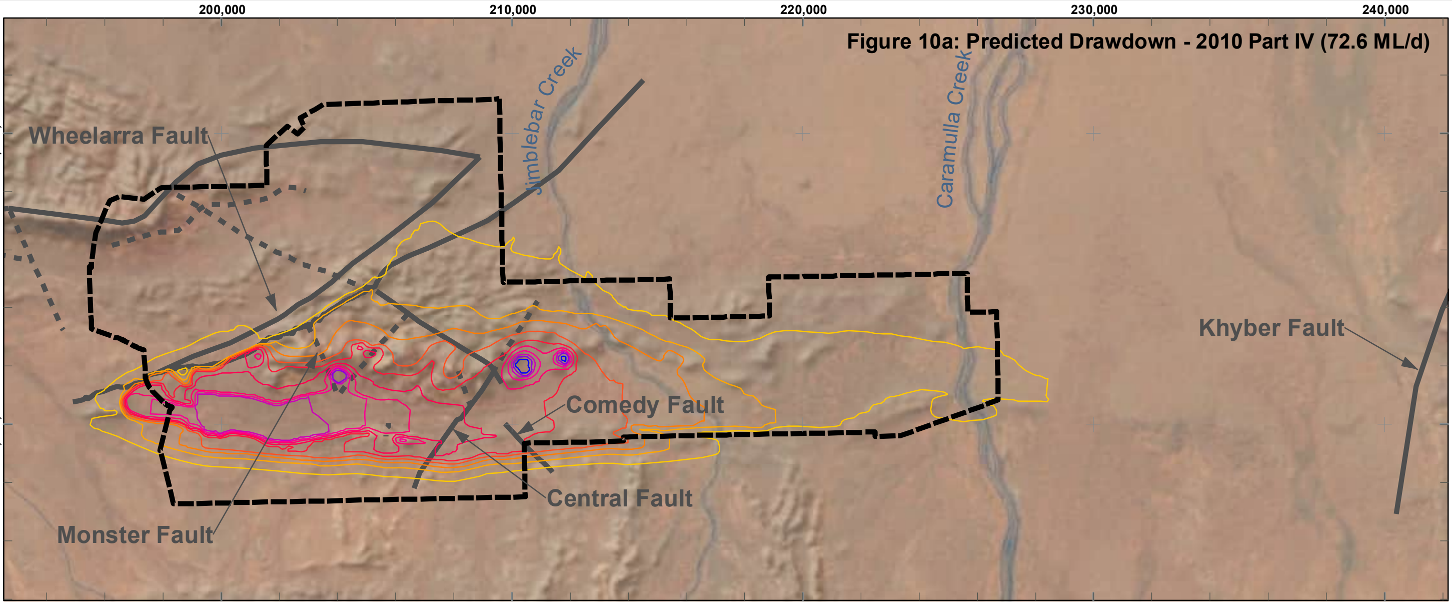
As the 2023 Jimblebar modelling includes predicted abstraction (including for dewatering) and drawdown from Jimblebar orebodies which have already been approved, it is necessary to understand the previously assessed abstraction and drawdown for the Jimblebar Approved Proposal, to determine the predicted change in the groundwater regime for the Jimblebar Hub Proposal (i.e. increase in groundwater abstraction for dewatering of the proposed East Jimblebar deposit and increase in dewatering of approved deposits at the Jimblebar mine). The results from previous groundwater assessments and the results from the 2023 Jimblebar numerical modelling were used to quantify the changes in the Jimblebar mine groundwater abstraction and drawdown (which forms part of the Jimblebar Hub Proposal).

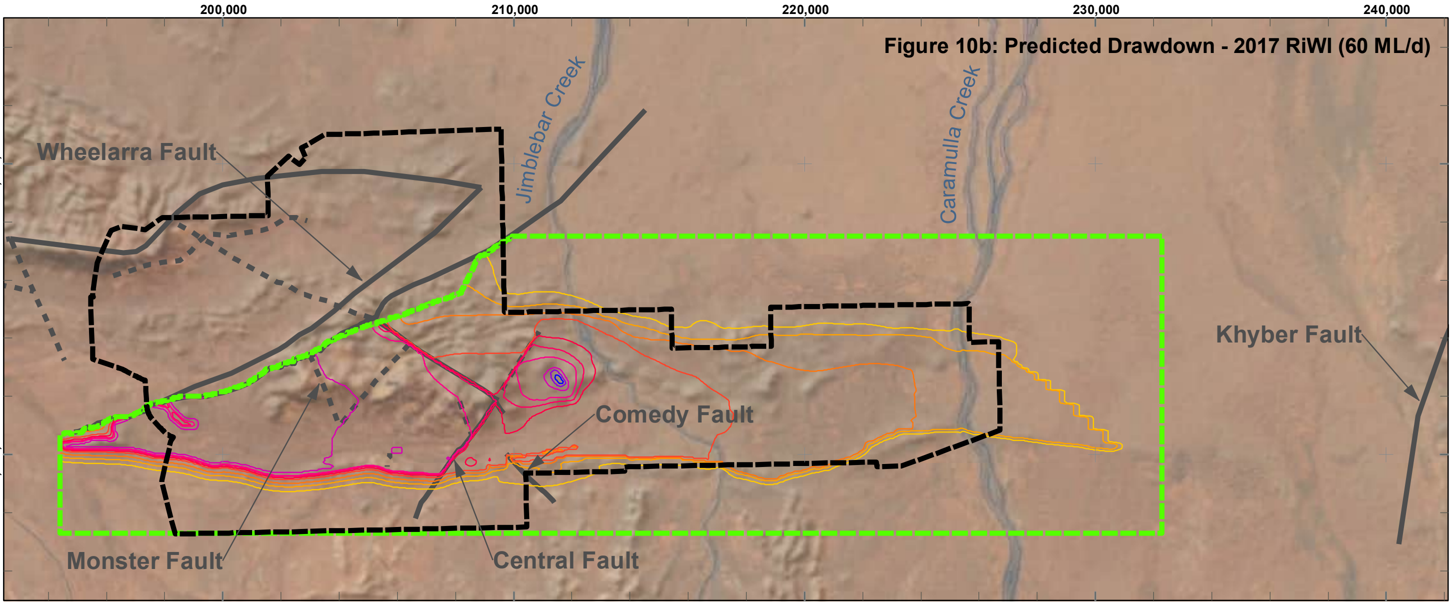
7.1.1 Assessed abstraction and drawdown for the Jimblebar Approved Proposal

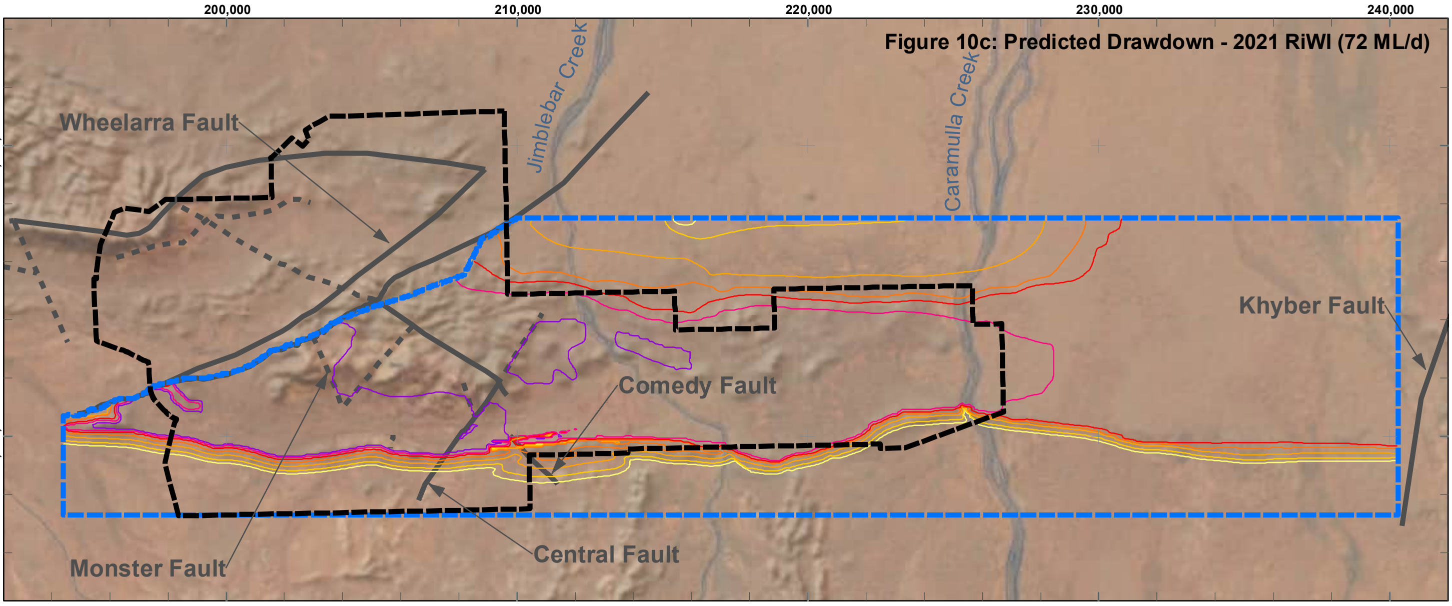
The following summarises the results and conclusions from groundwater abstraction and drawdown assessments previously undertaken for the Jimblebar mine Approved Proposal.

Groundwater abstraction for the Jimblebar mine Approved Proposal was last assessed under Part IV of the EP Act in 2010. As discussed in the *Jimblebar Iron Ore Project Environmental Protection Statement* (Jimblebar EPS) (BHP Billiton 2010), the pits were estimated to extend up to 190 m below the water table. The groundwater modelling predicted that a peak of 72.6 ML/d (26.5 GL/a) groundwater abstraction would be required for the High Case dewatering scenario (72.1 ML/d dewatering and 0.5 ML/d water supply) (BHP Billiton 2010; Table 3.4). Note that EPA Report 1371 (EPA 2010) for the Jimblebar Iron Ore Project refers to an abstraction rate range from 1.2 to 59.5 ML/d, however 59.5 ML/d was the second highest rate referred to in Table 3.4 of the Jimblebar EPS, not the peak rate (72.6 ML/d).

Groundwater abstraction of up to 60 ML/d (22 GL/a) for similar mine plan pit depths as the 2010 Part IV assessment was assessed under s5C of the RiWI Act in 2017 (BHP 2017) and authorised under s5C Licence to Take Water GWL158795(10) in 2018. The predicted vertical and lateral extent of drawdown for the 2017 RiWI 60 ML/d assessment was similar to the 2010 predicted assessed under Part IV of the EP Act. An increase in groundwater abstraction of up to 72 ML/d to align with the 2010 Part IV assessment was subsequently assessed under s5C of the RiWI Act in 2021 (BHP 2021c) and authorised under Jimblebar s5C Licence to Take Water GWL158795(11) in 2021. The 2021 model updates included extending the model domain and revising the hydrostratigraphy to the east to remove a dyke. The predicted maximum vertical drawdown for the 2021 RiWI 72 ML/d assessment was similar to the 2010 predicted drawdown assessed under Part IV of the EP Act. However, the predicted lateral drawdown extended approximately 10 km further to the east, due the change in the model stratigraphy (removal of the dyke) (BHP 2023c). Figure 10a,b,c presents a comparison of the predicted drawdown assessed for the Jimblebar Approved Proposal in 2010, 2017 and 2021 respectively.







Proposed Development Envelope

2017 model domain

2021 model domain

Flow barrier

Partial flow barrier

Predicted drawdown (m)

1

2

5

10

20

25

30

40

50

75

100

150

N

0 2 4 6

KILOMETRES

GDA 1994 MGA ZONE 51

BHP

PUBLIC

GROUNDWATER ENVIRONMENTAL IMPACT ASSESSMENT

Comparison of assessed drawdown for Approved Jimblebar Proposal

PLANNING & STANDARDS - IRON ORE

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7.1.2 Predicted 2023 Jimblebar groundwater abstraction and drawdown

As discussed in Section 6.2, the 2023 groundwater modelling predicts a peak dewatering rate of 137.7 ML/d (50.3 GL/a) from the Jimblebar mine. Note the peak rate is rounded to 140 ML/d in the hydrogeological assessment (BHP 2023c). To be conservative, BHP has assumed that a peak dewatering rate of up to 137.7 ML/d will be required and has evaluated the potential impact based on this. The selection of the run representing the highest dewatering rate (Run 19B) provides a higher level of confidence that dewatering volumes from the Jimblebar mine will be within the predicted range.

Figure 11a shows the predicted drawdown at the end of dewatering (2052) for Run19B (reproduced from Figure 8).

7.1.3 Change in Jimblebar groundwater abstraction and drawdown predictions

The 2023 Jimblebar predicted peak dewatering rate of 137.7 ML/d represents an increase of 65.1 ML/d (23.8 GL/a) compared to the 2010 Part IV assessed groundwater abstraction rate of 72.6 ML/d (26.5 GL/a) for the Jimblebar Approved Proposal.

Figure 11b shows the predicted drawdown at the end of dewatering for the most recent assessment of the Jimblebar Approved Proposal (i.e. s5C of the RiWI Act in 2021 for the peak dewatering rate of 72 ML/d), reproduced from Figure 10c. The predicted vertical and lateral drawdown for the Jimblebar 2023 modelling (corresponding to a peak dewatering rate of 137.7 ML/d) is similar to the predicted drawdown assessed under s5C of the RiWI Act in 2021 for the peak dewatering rate of 72 ML/d. Therefore, no additional drawdown from the Jimblebar mine is predicted compared to the most recent (2021 RiWI) assessment for the Jimblebar Approved Proposal.

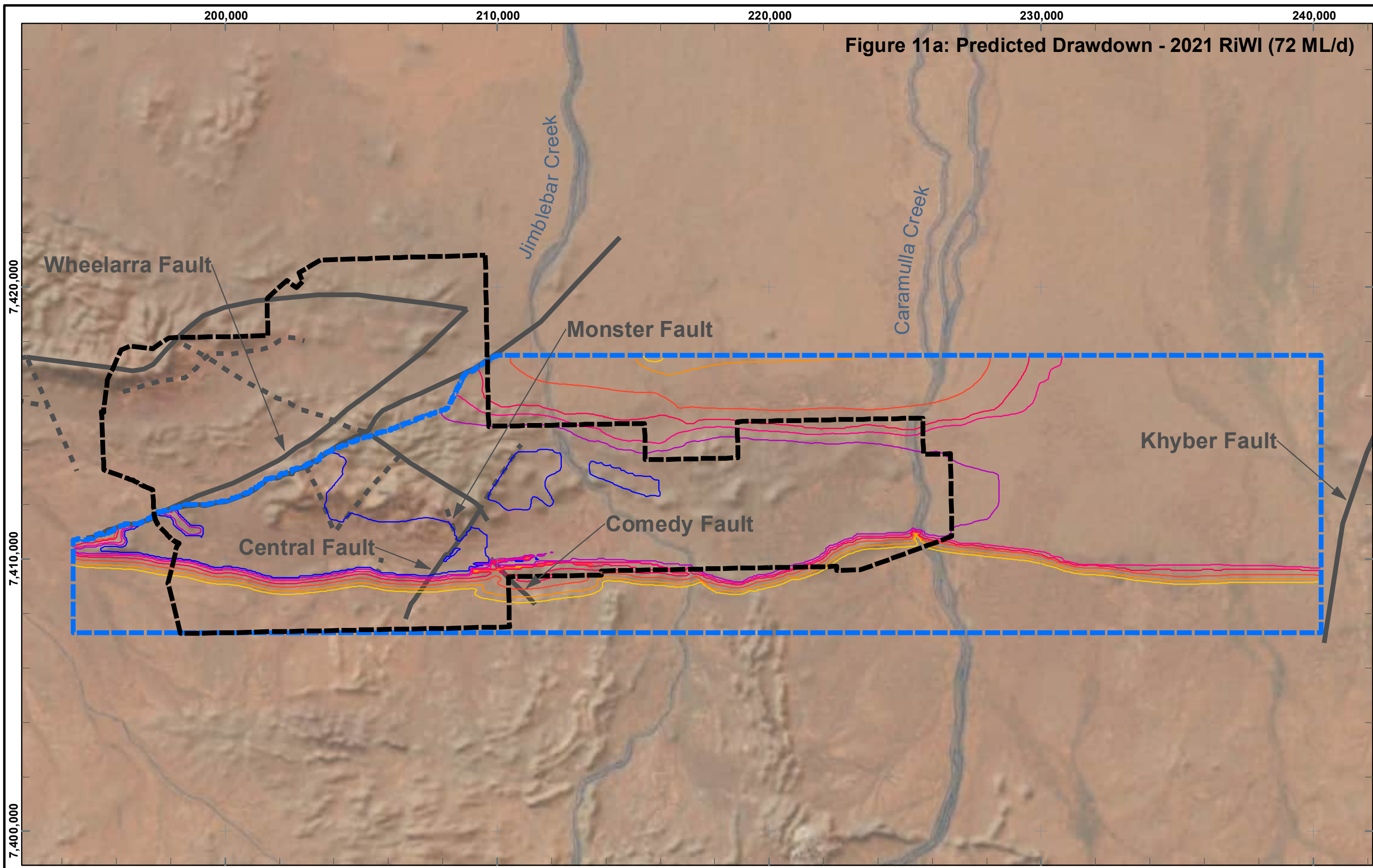

Figure 11a: Predicted Drawdown - 2021 RiWI (72 ML/d)

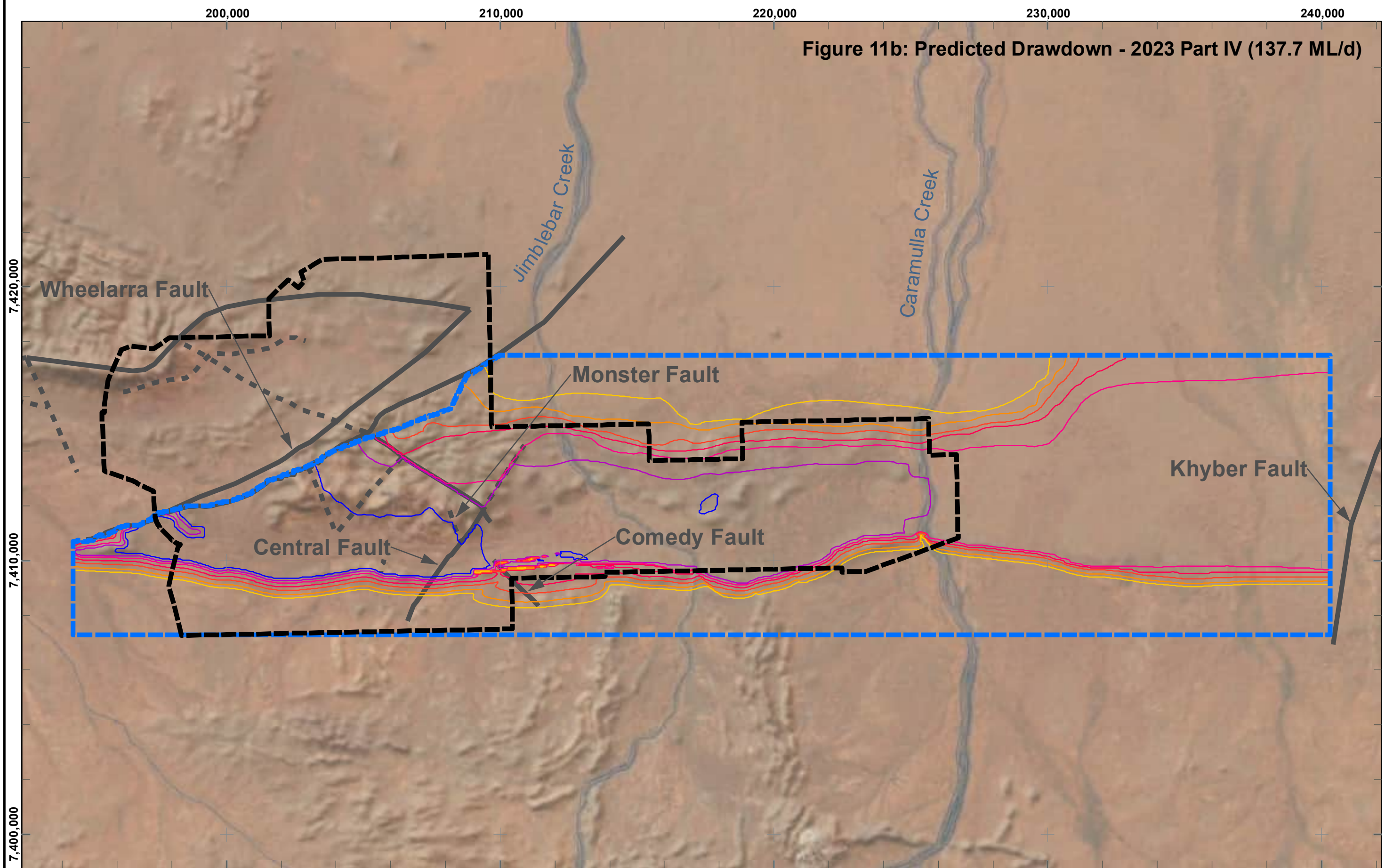

Figure 11b: Predicted Drawdown - 2023 Part IV (137.7 ML/d)

Proposed Development Envelope
Model domain
Flow barrier
Partial flow barrier

Predicted drawdown (m)

1
2
5
10
25
50
100

N

0 2 4 6
KILOMETRES
GDA 1994 MGA ZONE 51

BHP

PUBLIC

GROUNDWATER
ENVIRONMENTAL IMPACT ASSESSMENT
Comparison of assessed and
2023 predicted Jimblebar mine drawdown

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7.2 Combined Jimblebar Hub groundwater abstraction and drawdown

As discussed in Section 2, although no changes are proposed to the approved groundwater abstraction (including dewatering) rates for OB31 and OB17/18 in the Shovelanna area, as the Jimblebar Hub Proposal is a significant amendment to Approved Proposals in the Jimblebar Hub, BHP has considered the combined effects of the predicted change in abstraction and drawdown for the Jimblebar mine (see Section 7.1.3) in the context of the assessed abstraction and drawdown for the Jimblebar Hub Approved Proposals (existing Jimblebar, Orebody 31 and Orebody 18 mines).

7.2.1 Assessed abstraction and drawdown for the Jimblebar Hub Approved Proposals

Jimblebar mine

As discussed in Section 7.1.1, the abstraction assessed for the Jimblebar Approved Proposal is 72.6 ML/d (26.5 GL/a). Section 7.1.1 also summarises the assessed drawdown.

Orebody 18 mine

Groundwater abstraction (water supply and dewatering) of up to 2.8 GL/a and associated drawdown for the OB17/18 Approved Proposal was assessed under Part IV of the EP Act in 2007 for the *Orebody 18 Mine Modification - Application under Section 45C of the Environmental Protection Act, 1986* (BHP Billiton 2007).

Orebody 31 mine

Dewatering of up to 16.2 GL/a and associated drawdown for the OB31 Approved Proposal was assessed under Part IV of the EP Act in 2015. Drawdown from OB17/18 was assumed to cease once drawdown from OB31 started, however the predicted drawdown for OB31 extends across the OB17/18 area. A Base Case drawdown and Upper Bound drawdown was analysed in the *Orebody 31 Hydrogeological Impact Assessment: Summary Document* (BHP Billiton 2015), with the Base Case presented in the *Orebody 31 Iron Ore Mine Project Environmental Referral Document* (OB31 ERD) (BHP Billiton 2015b).

Therefore, the total groundwater abstraction assessed for the Jimblebar Hub Approved Proposals is 45.5 GL/a (26.5 GL/a for the Jimblebar mine, 16.2 GL/a for the Orebody 31 mine and 2.8 GL/a for the Orebody 18 mine).

7.2.2 Combined abstraction and drawdown for the Jimblebar Hub

The combined predicted groundwater abstraction for the Jimblebar Hub is 69.2 GL/a (total of 45.5 GL/a for the Approved Proposals as presented in Section 7.2.1) and 23.8 GL/a for the predicted change in the Jimblebar mine abstraction (discussed in Section 7.1.3).

To understand the combined predicted drawdown from the Jimblebar Hub groundwater abstraction, BHP has considered the following:

- assessed 2010 Part IV predicted drawdown for the Jimblebar Approved Proposal (as shown in Figure 10a in Section 7.1.1)
- assessed 2014 Part IV predicted drawdown for the OB31 Approved Proposal, as presented in the OB31 ERD (see Section 7.2.1)

predicted 2023 drawdown for the Jimblebar mine (as shown in

- Figure 11b in Section 7.1.3).

Figure 12 shows the following:

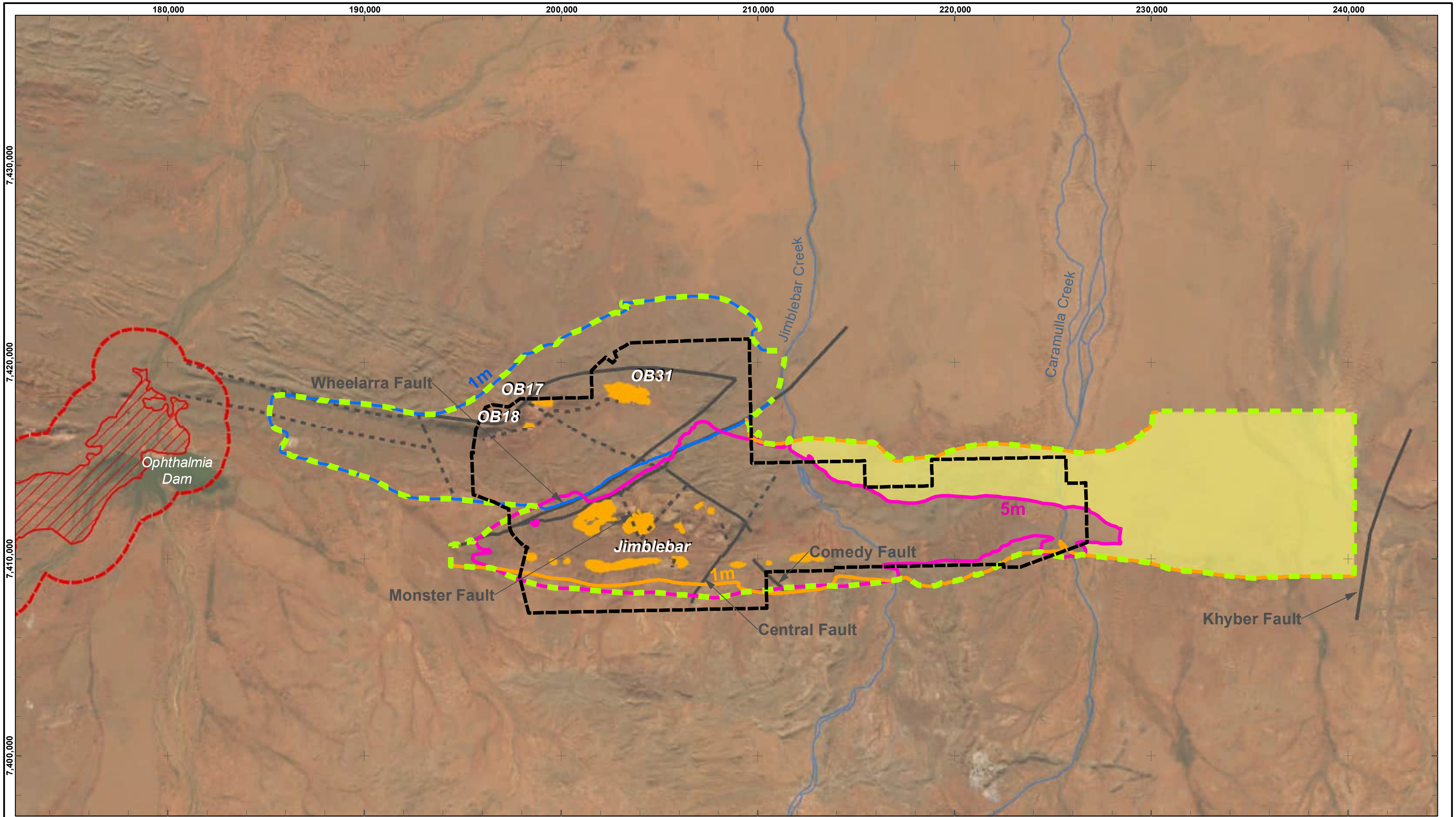
- 2010 Jimblebar 5 m Drawdown Contour: represents the predicted drawdown extent from the 2010 Part IV assessment for the Jimblebar mine
- 2014 OB31 1 m Drawdown Contour: represents the predicted drawdown extent from the 2015 Part IV assessment for the OB31 mine

- 2023 Jimblebar 1 m Drawdown Contour: represents the predicted drawdown extent from the 2023 Part IV assessment for the Jimblebar mine
- 2023 Combined Jimblebar Hub Drawdown Contour: represents the estimated maximum lateral extent of the assessed and proposed drawdown
- Jimblebar Hub Additional Drawdown: represents the predicted drawdown extent in addition to the drawdown assessed under Part IV for the Jimblebar, Orebody 31 and Orebody 18.

Predictive confidence is high in the western aquifer compartment of the Jimblebar mine area, where most dewatering activity has historically occurred. Drawdown is not predicted to migrate west of the Wheelarra Fault so there is no predicted additional drawdown in the Shovelanna (OB31 and OB17/18) mine area. Drawdown is not predicted to extend to the south due to the granite bedrock. Predictive confidence in the eastern aquifer compartment is moderate (western half) to low (eastern half). This compartment is much larger than the western aquifer compartment and has only recently been subjected to dewatering stresses. Drawdown is predicted to propagate to the east in the regional aquifers until it reaches the hydraulic barrier (Khyber Fault) (Figure 2 and Figure 12). The future migration and magnitude of drawdown to the north is less certain (BHP 2023c).

The lateral drawdown extent from the 2023 Jimblebar groundwater modelling is predicted to increase (all to the east) compared to the assessed Part IV drawdown for the Jimblebar Hub Approved Proposals (Jimblebar, Orebody 31 and Orebody 18 mines) at the end of the modelled dewatering period. The predicted additional vertical drawdown east of the Jimblebar mine will be up to 25 to 50 m deeper at the end of BWT mining when dewatering ceases (BHP 2023c) compared to the 2010 Part IV assessed drawdown. As previously assessed for the Orebody 31 mine in 2015 (as shown in Figure 12), predicted drawdown from the Shovelanna area to the west will not reach the Ethel Gorge TEC.

Although the analysis presented in Section 7.1.3 indicates that no additional drawdown from the Jimblebar mine is predicted for the 2023 modelling compared to the most recent (2021 RiWI) assessment for the Jimblebar mine Approved Proposal, when considering the combined changes since the Jimblebar Iron Ore Project was assessed in 2010 under Part IV of the EP Act, predicted drawdown has increased (represented by the Jimblebar Hub Additional Drawdown in Figure 12). As the 2021 RiWI assessment did not explicitly consider potential impacts to ecological receptors, BHP will consider this additional area of drawdown to assess potential impacts of the Jimblebar Hub Proposal on the EPA's biological factors.



Proposed Development Envelope
2023 Combined Jimblebar Hub Drawdown Contour
2023 Jimblebar 1m Drawdown Contour
2010 Jimblebar 5m Drawdown Contour
2015 OB31 1m Drawdown Contour
Jimblebar Hub Additional Drawdown
Ethel Gorge TEC
TEC 2km buffer
Flow barrier
Partial flow barrier
Existing pits

N
0 2 4 6
KILOMETRES
GDA 1994 MGA ZONE 51

BHP

PUBLIC

GROUNDWATER
ENVIRONMENTAL IMPACT ASSESSMENT
Jimblebar Hub combined predicted drawdown extent

PLANNING & STANDARDS - IRON ORE

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8 Post-mining groundwater level change assessment

This section presents the assessment of post-mining (closure) for the following:

- change in predicted groundwater level recovery for the Jimblebar mine only (as there are no proposed changes to the approved dewatering rates for the Orebody 31 and Orebody 18 mines), compared to previously assessed groundwater level recovery (Section 8.1)
- combined effects of post-mining groundwater level change for the Jimblebar mine and for the Approved Proposals in the Jimblebar Hub (the existing Jimblebar, Orebody 31 and Orebody 18 mines) (Section 8.2).

8.1 Jimblebar mine post-mining groundwater level recovery

8.1.1 Assessed post-mining groundwater recovery for the Jimblebar Approved Proposal

The following summarises the results and conclusions from groundwater recovery assessments previously undertaken for the Jimblebar mine Approved Proposal.

The post-mining hydrogeological assessment for the Jimblebar Iron Ore Project (BHP 2010) assumed the following:

- Jimblebar South pits: progressive backfill to 5 m above the pre-mining groundwater level
- Wheelarra Hill and Hashimoto pits: no-backfill (i.e. void).

For Jimblebar South, groundwater levels in the backfilled voids were predicted to recover by up to 60% to within 70 m of the pre-mining groundwater level of 462 mAHD (392 mAHD) within 5 years after dewatering ceases. For the High Case dewatering scenario, 70 to 80% recovery was predicted after 250 years. The pre-mining groundwater flow pattern (i.e. northerly flow through the orebody area) would be re-established once groundwater levels in the backfilled pits recovered to higher levels than in the adjacent dolomite/alluvium aquifers (Aquaterra 2009).

For Wheelarra Hill and Hashimoto (no-backfill), water levels in the voids (pit lakes) were predicted to reach equilibrium (where groundwater inflows balance evaporation) between approximately 400 to 430 mAHD (30 m to 60 m below the pre-mining groundwater level of 460 mAHD) within 50 years in all pits. Therefore, the pit voids would remain groundwater sinks.

8.1.2 Predicted 2023 Jimblebar post-mining groundwater level recovery

As discussed in Section 6.3, the 2023 groundwater modelling predicts that groundwater levels will recover to 340 to 360 mRL for the no-backfill scenario and 340 to 380 mRL for the scenario with the backfill of selected pits. The time period for recovery to equilibrium water levels could be between 500 and 3,000 years.

8.1.3 Change in Jimblebar post-mining groundwater level recovery predictions

As discussed in Section 8.1.1, the 2010 assessment (for the backfill of selected pits) predicted that groundwater levels would recovery to between approximately 390 and 430 mAHD. As discussed in Section 8.1.2, the 2023 Jimblebar modelling predicts that groundwater levels will recover to between 340 and 380 mRL. Therefore, the 2023 Jimblebar modelling predicts that the final pit lake water levels and groundwater levels could be up to 50 m lower than the predicted 2010 water levels.

8.2 Combined Jimblebar Hub post-mining groundwater level changes

Jimblebar mine

As discussed in Section 8.1.3, the 2023 Jimblebar modelling predicts that the final pit lake water levels (for the no-backfill and backfill of selected pits) could be between 340 and 380 mRL. However, due to the flow barriers (Wheelarra Fault in the west, low permeability granite bedrock to the south and Khyber Fault to the east), it is unlikely that groundwater would flow into the Western and Eastern Compartments from the surrounding aquifers.

Based on a backfill scenario analysis conducted in 2019, between 40 - 60% of mined overburden may be progressively backfilled into mined out pits at the Jimblebar mine. This is expected to minimise the extent of post-closure pit lakes. BHP's long-term beneficiation strategy may also contribute to backfill through the in-pit storage of tailings (BHP 2023d).

Orebody 18 mine

The recovery of post-mining groundwater levels for OB18 was modelled for the backfill (i.e. to above pre-mining groundwater level) scenario. It was estimated that groundwater levels within the backfilled pit voids would fully recover to pre-mining groundwater levels within 3 years after dewatering ceases (BHP Billiton 2007). As discussed in Section 4.2, the latest conceptualisation is that OB17 and OB31 are hydraulically connected and that OB18 is not hydraulically connected to OB17. Therefore, groundwater level recovery at OB17 is unlikely to occur until dewater at OB31 ceases.

The current closure strategy is that the below water table voids at OB17/18 will be backfilled with tailings or overburden (to at least 5 m above the pre-mining water table) (BHP 2023d).

Orebody 31 mine

The long-term hydrological change for OB31 was evaluated for three scenarios (BHP Billiton 2015a):

- backfill to 5 m above the pre-mining groundwater level
- partial backfill
- no-backfill (i.e. void).

The modelling predicted that groundwater levels within the backfilled void would recover by 100 m (75% recovery) within 50 years after dewatering ceases, 90% recovery after 300 years and full recovery after 600 years. The long-term hydrological state would return to the pre-mining gradient with groundwater through flow to the north and north-east. The modelling predicted that groundwater levels within the partially backfilled void would rebound by 55 m within 20 years after dewatering ceases, reaching an equilibrium of 65 m below the pre-mining groundwater level (425 mAHD) with 70 years. The no-backfill scenario predicted a slower recovery (approximately 100 years) to the equilibrium of 70 m below the pre-mining groundwater level (420 mAHD). For the partial or no-backfill (i.e. void) scenario, a pit lake will form. The level at which the pit lake will reach equilibrium is predicted to be lower than the regional groundwater level and groundwater would discharge to the pit lake (groundwater sink) (BHP Billiton 2015a).

The closure strategy for the OB31 mine void is under review, but BHP's long-term beneficiation strategy may also contribute to backfill through the in-pit storage of tailings (BHP 2023d).

9 References

Aquaterra (2009) *Hydrogeological Assessment for Jimblebar Iron Ore Project*. Appendix G to *Jimblebar Iron Ore Project Environmental Protection Statement* (BHP Billiton 2010).

BHP Billiton (2007) *Orebody 18 Mine Modification: Application under Section 45C of the Environmental Protection Act, 1986*. December 2007.

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BHP Billiton (2015a) *Orebody 31 Hydrogeological Impact Assessment: Summary Document*. Appendix I to *Orebody 31 Iron Ore Mine Project Environmental Referral Document*.

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BHP (2021) *Jimblebar Detailed Hydrogeological Assessment – 72ML/d.* September 2021.

BHP (2023a) *Jimblebar Hub Iron Ore Mining Operations Significant Amendment: Environmental Review Document – referral supplementary report*. December 2023.

BHP (2023b) *Jimblebar Hub: Ophthalmia Dam surplus water impact assessment update*. December 2023.

BHP (2023c) *Jimblebar Hydrogeological Assessment*. December 2023.

BHP (2023d) *Jimblebar Hub Mine Closure Plan*, Revision 0, BHP, Western Australia. December 2023.

Environmental Protection Authority (EPA) (2010) *Jimblebar Iron Ore Project: Report and recommendations of the Environmental Protection Authority*, EPA, Western Australia.

Appendices

Appendix A Jimblebar Hydrogeological Assessment