To:	HDB Town Planning and Design
Email:	Aprajita Gupta, Aprajita@hdb.com.au
Date:	14 June 2022
Subject:	Dalswinton Quarry Groundwater Impact Assessment – Response to DPE Advice
Project number:	4047

1. Introduction

hydrogeologist.com.au conducted a groundwater impact assessment in 2021 to support the Environmental Impact Statement (EIS) to expand the existing sand and gravel quarry operation at Dalswinton Quarry (the project). The EIS was prepared by HDB Town Planning and Design (HDB) on behalf of the proponent Rosebrook Sand and Gravel Pty Ltd (RSG)

Following submission of the EIS, a response was received from the NSW Department of Planning and Environment (DPE) Water and the Natural Resources Access Regulator (NRAR) requesting further information in respect to the groundwater impact assessment and management.

Additional numerical modelling has been carried out to address the recommendations provided in the DPE response. This memo details the additional numerical modelling that has been carried out and the further information that has been requested in the DPE response to the EIS.

2. DPE advice

The advice from DPE is summarised in the following sections.

2.1. Water take and licensing

Recommendations – prior to determination:

1.1 - The proponent should provide clarification of the maximum groundwater and surface water take, site water demands and the ability to obtain additional water entitlement where required for the project (see Section 3.3).

Recommendations – post approval:

1.2 - The proponent should ensure that:

1.2.a - Sufficient water entitlement is held in a Water Access Licence/s (WAL) to account for the maximum predicted take for each water source prior to take occurring during the project operational period and post closure unless an exception under the Water Management (General) Regulation 2018 applies (see Section 6).

1.2.b - Relevant nomination of work dealing applications for WALs proposed to account for water take by the project have been completed prior to the water take occurring (see Section 6).

2.2. Groundwater impact assessment and management

Recommendations – prior to determination:

2.1 - The proponent should:

2.1.a - Review the conceptualisation and how the conceptualisation is transferred to the numerical model to ensure aquifer interference activities and their impacts are represented in the groundwater model and have the ability to predict potential impacts on the river and aquifer (and other groundwater values) during and post closure of the quarry operation (see Section 3.2).

2.1.b - Assess the proposal against the Aquifer Interference Policy (AIP) requirements and include the summarised responses using the Aquifer Interference Assessment Framework Tool (see Section 4).

2.1.c - Review groundwater inputs to include groundwater take that includes evaporative groundwater loss from the voids; incidental take with quarried aggregates; and dewatering and take for processing demands (see Section 3.2.1 and 3.2.2). This would also include the need to clarify whether post closure void (landform) intercepts aquifers, and if so, estimate the ongoing groundwater take post closure (see Section 3.2.3).

2.1.d - Base the groundwater model on a complex modelling platform that is consistent with the Australian Modelling Guidelines; independently reviewed; and determined to be robust and reliable; and deemed fit for purpose (see Section 3.1).

Recommendations – post approval:

The proponent should:

2.2.a - Develop a monitoring plan to measure the groundwater inflow into the quarry to confirm take predictions, and the adequacy of mitigating measures and compliance for water take (see Section 5).

2.2.b - Review annually the measured groundwater inflow into the quarry pits after quarry operations deepens into aquifers. This will ensure sufficient entitlement is held in the WAL prior to take (see Section 5).

2.2.c - Develop a water management plan that follows the Guidelines for Groundwater Documentation for NSW Major Projects. This should include the construction and placement of new monitoring bores, frequency of monitoring, water quality analysis suites and trigger action response plan. Performance against this plan should be reported annually (see Section 5).

3. Numerical modelling

3.1. Modelling platform and classification

The project numerical groundwater flow model (the model) was developed using MODFLOW-USG code. The MODFLOW code, on which MODFLOW-USG is based, is the most widely used code for groundwater modelling and is presently considered an industry standard. Use of the MODFLOW-USG modelling package is widespread, particularly in mining applications in New South Wales to simulate groundwater dewatering and recovery. MODFLOW-USG is considered to be a complex modelling platform consistent with the recommendations of the Australian Modelling Guidelines (Barnett *et al.*, 2012).

MODFLOW-USG has been considered suitable for the project as it:

- allows the use of an unstructured mesh where cells can be refined around localised features such as rivers, alluvial aquifers and quarry pits, and larger cells used where refinement is not required; and
- does not need layers to be continuous over the model domain, allowing layers to stop where geological units (such as alluvium) pinch out.

The degree of confidence with which model predictions can be used are described using a 'confidence classification' scale which is presented as part of the Australian Groundwater Modelling Guidelines (Barnett *et al.*, 2012). The classification scale conveys understanding about the model complexity, level of calibration and potential for the predictions to be incorrect. The model can fall into three classes:

- *Class 1* – the simplest model, often not calibrated, used as starting points for more complex models, used for prediction of low-value aquifers, least amount of confidence in the modelling results;
- *Class 2* – more complex models, prediction capability could vary depending on the location within the model domain, calibration and prediction runs can vary in terms of magnitude of model stresses and time discretisation, used for prediction in medium- or high-value aquifers; and
- *Class 3* – detailed and complex models, high trust in validity of modelling predictions, used to simulate detailed, small-scale processes, used for predictions in high-value aquifers, the highest amount of confidence in the results of the modelling.

Barnett *et al.*, (2012) state that every model should be evaluated using multiple criteria, that is:

- available data, accuracy of the data, spatial and temporal distribution of the data;
- quality of calibration process undertaken during model development;
- consistency between the calibration and predictive analysis; and
- the level of stresses applied to the predictive model.

The groundwater model developed for the project is considered a Class 1 model due to:

- the relative lack of site-specific groundwater information; and
- the steady-state calibration.

However, a Class 1 model is considered appropriate in this instance. The steady-state calibration aims to reduce the residual error of groundwater level data which are derived predominantly from alluvial bores in the model domain. By doing this, the calibration provides a suitable approximation of the bulk hydraulic conductivity of the alluvium throughout the model domain. The steady-state calibration achieved a 7.6% scaled root mean square error (SRMS), indicating that there is a good correlation between the measured and observed heads in the calibration model, and that the model can be considered robust and reliable. The calibrated horizontal hydraulic conductivity was 12 .8 m/day for the modelled alluvium, appropriately representing the high hydraulic conductivity of the aquifer.

Given the proximity of the project to the Hunter River, there will be a direct hydraulic connection between the quarry operations and the Hunter River. In general, the influence of the Hunter River on the quarry operations will be dependent upon the hydraulic conductivity of the alluvial sediments. Where the hydraulic conductivity is high, the groundwater levels in the alluvium will be behave in unison with the surface water levels in the Hunter River and during periods of higher water levels the evaporative losses will maximise. Where the hydraulic conductivity is low, there will be less interaction with the Hunter River, less inflow and less evaporative loss. By calibrating to a high hydraulic conductivity value, the model represents the real-world conditions. Historical monthly average levels from the surface water gauging stations have been used to assign river elevations in the predictive model. The use of the historical data, along with high hydraulic conductivity, means that the model is considered appropriate to use as a predictive model to assess a plausible range of seasonal influences and to assess the likely maximum inflow to the proposed quarry operations. On this basis, the model is considered fit for purpose for estimating the impacts of the project. Once site specific data is available, the model can be further developed and calibrated to improve the predictive capacity.

While internal peer review was conducted by **hydrogeologist.com.au** during the model construction and development process, a third-party review has not yet been carried out. The proponent commits to engaging a third-party to conduct an independent review of the groundwater model. The proponent commits to making any required updates or suggested improvements to the groundwater model post approval.

3.2. Conceptual model

3.2.1. Groundwater surface water interaction

The groundwater regime in the project area consists of three hydrostratigraphic units, including:

- alluvium associated with the Hunter River;
- shallow weathered bedrock (regolith); and
- deeper, fresh Permian strata.

The project will directly impact the Hunter River alluvial water source through the quarrying and removal of sand and gravel sediments. The Hunter River alluvial water source contains shallow groundwater and is classified as a high yield aquifer. The geometry and characteristics of the Hunter River alluvium are understood from geological site investigations and the current quarrying activities.

The Hunter River alluvial water source is in direct hydraulic connection to the Hunter River, which is located immediately adjacent to the project area. Groundwater levels within the Hunter River alluvial water source are predicted to be significantly influenced by the level of surface water within the Hunter River, resulting in groundwater levels and trends within the alluvium that strongly correlate to the levels of the Hunter River. This concept is confirmed at several long term groundwater monitoring bore sites and river gauging stations both upstream and downstream of the project site. Due to the direct hydraulic connection between the Hunter River alluvial water source and the Hunter River, it is predicted that the project will take water from both the Hunter River alluvial water source and the Hunter River.

The Hunter River is a perennial watercourse which is supplemented by upstream water storages. There are three gauging stations located near the project which provide a long term, transient record of surface water elevations and flows. Whilst no site-specific groundwater level data is available, the availability of long term, transient records of surface water elevations and flows allows for the extrapolation of this data along the alignment of the Hunter River. The representation of the Hunter River and other tributaries within the numerical model is shown below in Figure 3.1 and is further summarised in the original groundwater impact assessment.

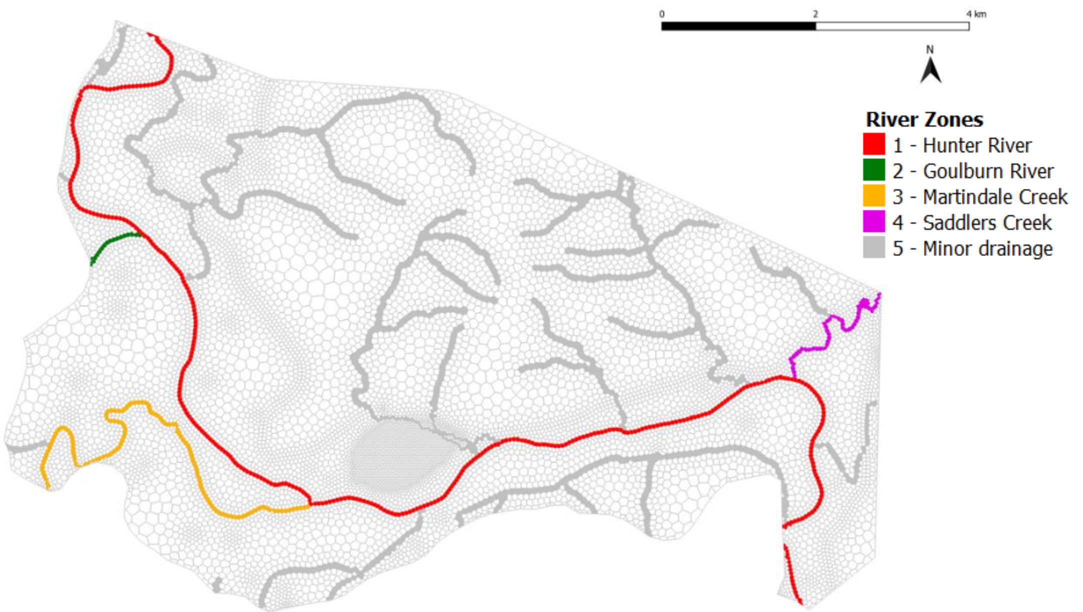

Figure 3.1 Representation of the Hunter River – shown in red

The Hunter River is numerically represented in the model using the RIV package. Steady-state river stage elevations for the Hunter River were based on the long-term averages from gauging stations at Denman (GS 210055) and Liddell (GS 210083). These were then extrapolated along the length of the Hunter River alignment. For the transient simulation, river stage elevations were varied based on the historical monthly average levels from the gauging stations and were extrapolated along the length of the Hunter River alignment. During average periods of high surface water elevations in the Hunter River, the RIV package allows additional water to enter the model domain to flow into the alluvial sediments. Therefore, the model is able to simulate the interaction between the Hunter River and the Hunter River alluvial water source and allows for seasonality.

Section 3.3 provides the model output from the RIV package. This represents the predicted water take from the Hunter River water source.

3.2.2. Quarrying and water take

The proposed quarrying operations are highly likely to intersect the groundwater table during operations. This is consistent with the conditions observed in the current quarry operations.

The exposure of the groundwater table in the proposed quarry operation will result in evaporative losses from the Hunter River alluvial water source. The EVT package was used to simulate the groundwater take from evaporation in the model. The model was updated to have a consistent five (5) hectares (ha) of excavation area across the entire life of the project. The modelled excavation area moved progressively across the project area to simulate the migration of the quarry pits over the proposed 25-year life of operation. The proponent has committed to progressively back filling and rehabilitating excavated areas in order to minimise the exposure of the groundwater table during operations.

Additionally, the model was updated to allow for the take of groundwater associated with the incidental moisture content of the quarried aggregates and direct take for processing demands. The predicted volume of direct take for processing demands was taken from the median values of the project surface water balance for haul road dust suppression (38.7 ML/yr – see Table 4.2 of the project surface water impact assessment) and process plant demand / moisture lost with product (7.5 ML/yr – see Table 4.2 of the project surface water impact assessment), for a total direct take of 46.2 ML/yr. The direct take was simulated in the model using the WEL package. The location of the wells applied with the WEL package were moved around the project area each year to simulate the progressive migration of the quarry pits over the proposed 25-year life of operation.

By representing the effects of quarrying and the direct water take, the model is able to predict the likely water take from the Hunter River alluvial water source. Section 3.3 provides the model predictions for the EVT package, which represent the direct water take from the Hunter River alluvial water source.

3.2.3. Post closure

Post closure, the proponent has committed to having at least two (2) metres of cover above the groundwater table on all rehabilitated areas. There will be no exposed windows into the groundwater table, which will minimise the post closure take of water to be as low as reasonably practical. Therefore, there will be no final void(s) intercepting the Hunter River alluvial water source in the project area.

3.3. Numerical modelling results

As discussed above in Sections 3.2.1 and 3.2.2, the model was updated to ensure that the extent of the quarry excavation (and the window into the groundwater table) is a consistent 5 ha across the entire mine life of the project. The model has also been modified to include the direct take of water associated with the incidental moisture of the quarried aggregates and direct take for processing demands.

Figure 3.2 and Table 3.1 show the predicted (direct and indirect) water take for the project. The green bars represent the predicted annual take of water for haul road dust suppression and process plant demand / moisture lost with product (direct take) is a consistent 46.2 ML/yr (as per Table 4.2 of the project surface water impact assessment). The predicted annual take of water due to evaporative loss from the quarry extraction (direct take) is shown in grey. The predicted annual loss of surface water from the Hunter River water source as a result of the project (indirect loss) is shown in blue.

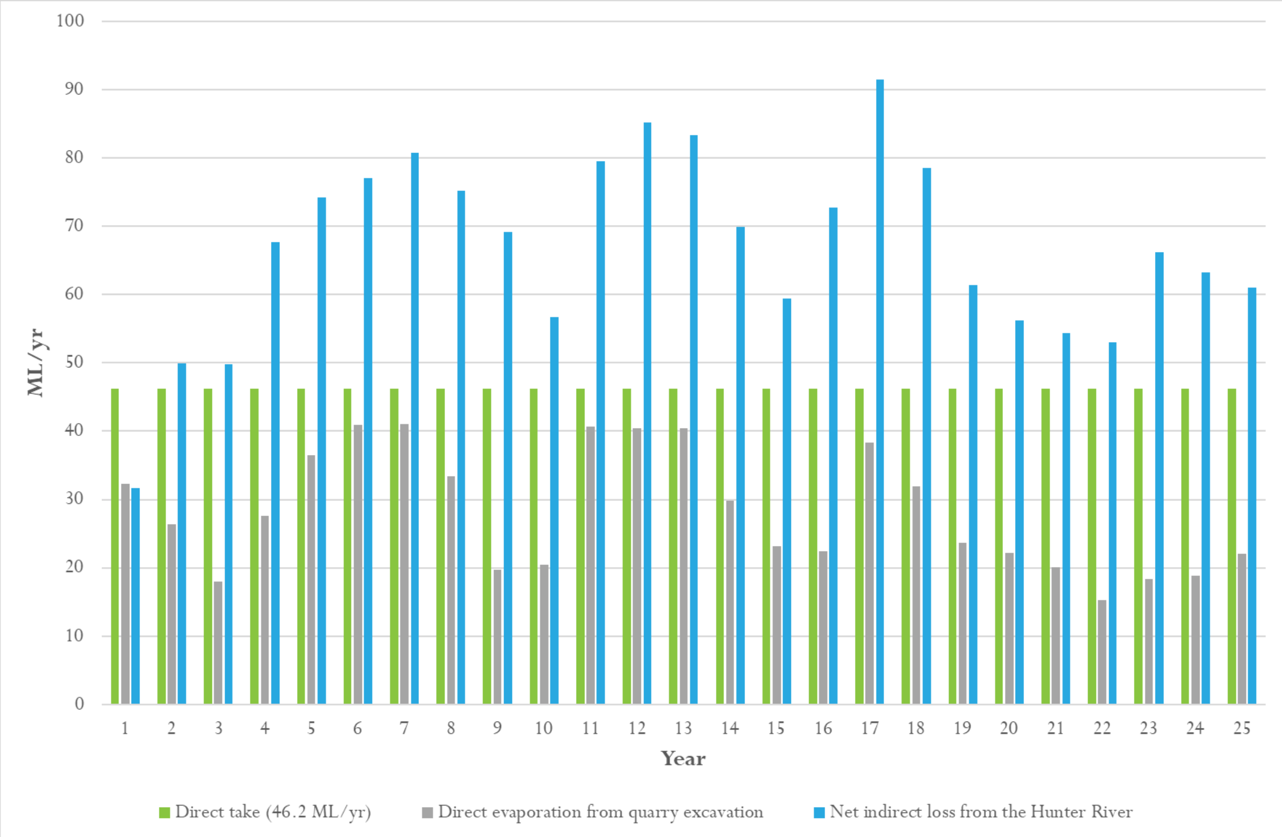

Figure 3.2 Predicted model outputs

Table 3.1 Summary of the predicted model outputs

Year	Direct take (ML/yr)	Direct evaporation (ML/yr)	Net direct take from the Hunter River alluvium (ML/yr)	Net indirect loss from the Hunter River water source (ML/yr)
1	46.2	32.26	78.46	31.67
2	46.2	26.40	72.60	49.96
3	46.2	17.93	64.13	49.76
4	46.2	27.57	73.77	67.70
5	46.2	36.45	82.65	74.15
6	46.2	40.92	87.12	77.02
7	46.2	41.08	87.28	80.71
8	46.2	33.44	79.64	75.22
9	46.2	19.72	65.92	69.20
10	46.2	20.50	66.70	56.74
11	46.2	40.67	86.87	79.53
12	46.2	40.48	86.68	85.12
13	46.2	40.47	86.67	83.33
14	46.2	29.85	76.05	69.91
15	46.2	23.19	69.39	59.37
16	46.2	22.47	68.67	72.70
17	46.2	38.37	84.57	91.52
18	46.2	31.93	78.13	78.54

Year	Direct take (ML/yr)	Direct evaporation (ML/yr)	Net direct take from the Hunter River alluvium (ML/yr)	Net indirect loss from the Hunter River water source (ML/yr)
19	46.2	23.67	69.87	61.40
20	46.2	22.13	68.33	56.17
21	46.2	20.02	66.22	54.40
22	46.2	15.32	61.52	53.06
23	46.2	18.38	64.58	66.20
24	46.2	18.86	65.06	63.28
25	46.2	22.01	68.21	60.98

Figure 3.2 illustrates that the direct take and direct evaporative take from the Hunter River alluvial water source results in a corresponding net loss of water from the Hunter River water source. This is expected given the proximity of the Hunter River to the project site. The perennial nature of the Hunter River provides a source to replenish groundwater that is directly and indirectly extracted by the project. Table 3.2 indicates that the direct take of water for the project is largely sourced indirectly from the Hunter River water source.

Figure 3.3 shows the predicted water take by the project from the Hunter River and Hunter River alluvial water source respectively. The bulk of the water predicted to be extracted by the project comes from the Hunter River (with a maximum of 91.52 ML/yr in Year 17), whereas the water taken from storage in the Hunter River alluvial water source comprises a small percentage of the overall water take. The exception to this is in the first three years of operation where the storage in the alluvium is initially depleted. This depletion causes localised drawdown in the alluvium which then induces flow from the Hunter River into the alluvium to compensate for the drawdown. In the first year of operation there is 46.79 ML/yr taken from the Hunter River alluvial water source. This rapidly decreases to generally less than 10 ML/yr in Year 4.

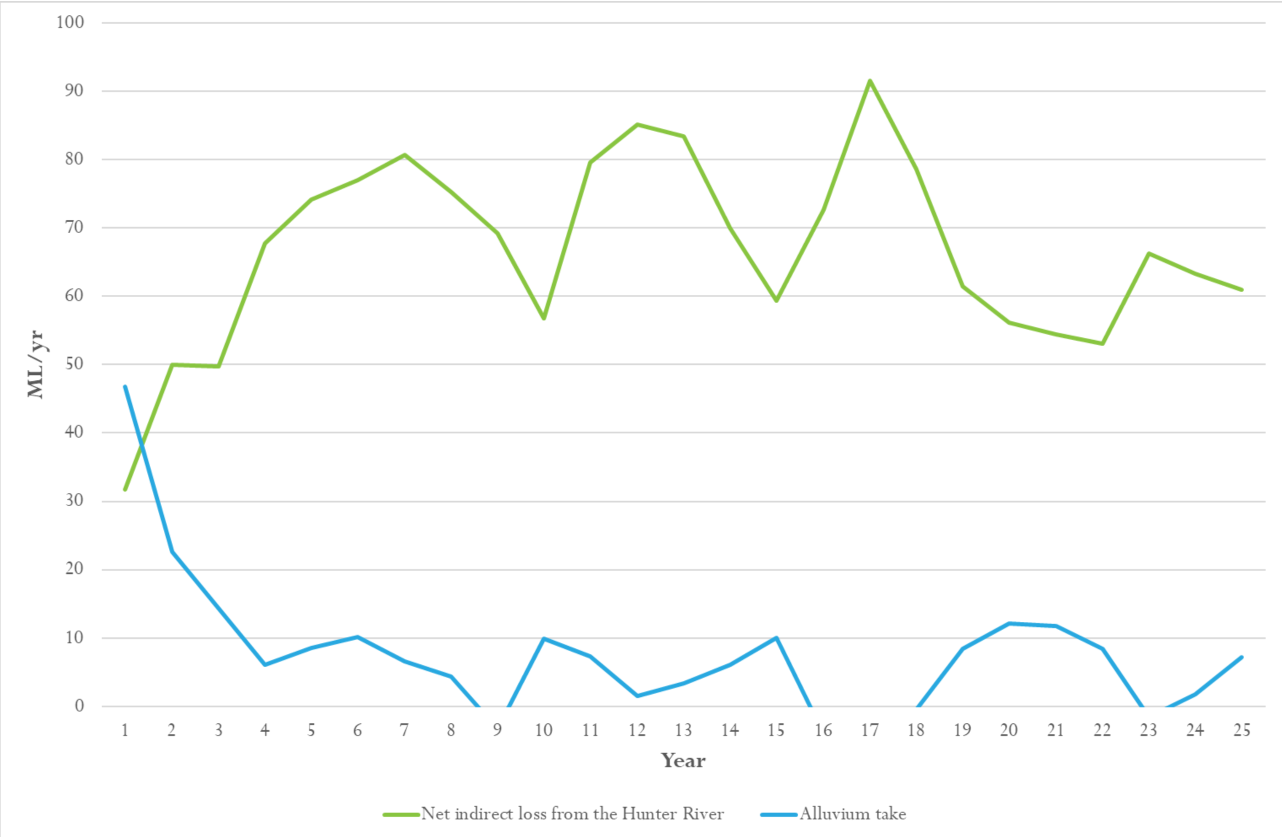

Figure 3.3 Predicted water take

Table 3.2 Summary of predicted water take

Year	Net indirect loss from the Hunter River (ML/yr)	Alluvium take (ML/yr)
1	31.67	**46.79**
2	49.96	22.63
3	49.76	14.37
4	67.70	6.06
5	74.15	8.50
6	77.02	10.10
7	80.71	6.57
8	75.22	4.42
9	69.20	0
10	56.74	9.96
11	79.53	7.34
12	85.12	1.56
13	83.33	3.33
14	69.91	6.15
15	59.37	10.02
16	72.70	0
17	91.52	0
18	78.54	0
19	61.40	8.47
20	56.17	12.16
21	54.40	11.82
22	53.06	8.46
23	66.20	0
24	63.28	1.78
25	60.98	7.23

The reader is directed to the project surface water impact assessment for an assessment of the available water access licences (WAL). However, the proponent is committed to having the necessary WAL for the respective Water Sharing Plans in place prior to operations.

The maximum predicted drawdown (reduction in groundwater level) over the life of the Project is presented in Figure 3.4. The predicted maximum drawdown is larger in extent compared to that presented in the original groundwater assessment due to the larger extent of quarry pits over both work areas. The predicted maximum drawdown is 4.4 m, with drawdown predicted to extend a maximum distance of 640 m from the project boundary (to the west). The 1 m drawdown contour is generally predicted to stay within the project area.

Figure 3.4 also shows the maximum predicted drawdown in relation to the potential GDEs located within and adjacent to the project area. Where maximum drawdown is predicted to encroach on the low-potential GDEs, the temporal nature of the drawdown would suggest recovery as the quarry location moves away from the GDEs or on the cessation of quarrying. As such, it is assessed that there is unlikely to be any impact of the Project development to any potential GDE sites.

Figure 3.4 also shows the maximum predicted drawdown in relation to private water supply bores located within and adjacent to the project area. There are 11 bores located within the predicted extent of maximum drawdown. Several of these bores are located on the proponent's property and are classified as abandoned. The two bores located to the west of the project area (GW018790 and GW018791). Bore GW018791 is located just outside of the maximum predicted drawdown extent whereas there is 0.26 m of drawdown predicted to occur at GW018790. The cluster of five (5) bores on the northern perimeter of the project area are all monitoring bores and are not used for water supply purposes.

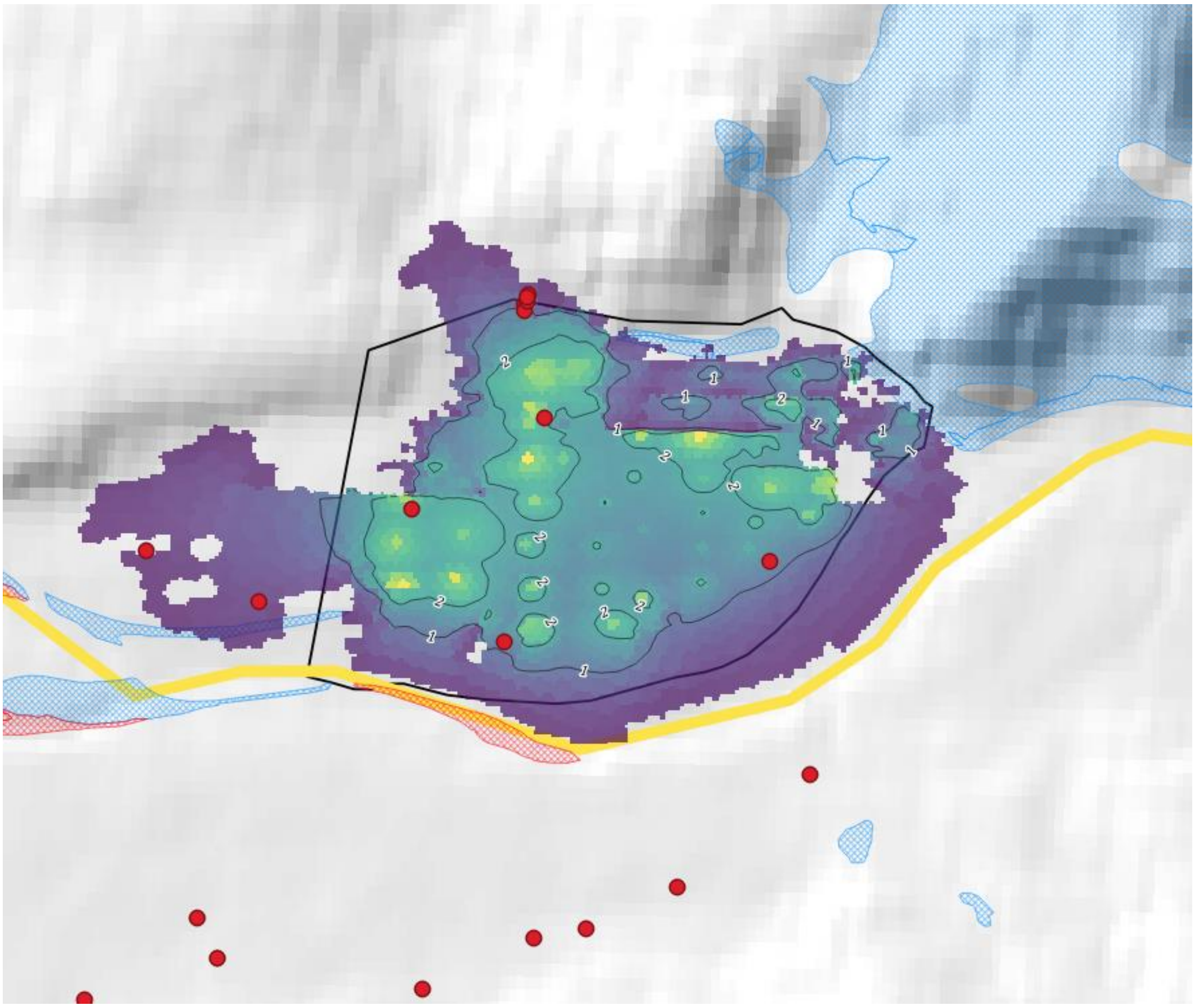

Figure 3.4 Predicted maximum drawdown (m)

4. Aquifer interference assessment framework

The following section and Table 4.1 to Table 4.5 describes the Aquifer Interference Policy (AIP) requirements and includes summarised responses using the Aquifer Interference Assessment Framework Tool.

Table 4.1 Does the activity require detailed assessment under the AIP?

	AIP requirement	Proponent response
1	Is the activity defined as an aquifer interference activity?	Yes
2	Is the activity a defined minimal impact aquifer interference activity according to Section 3.3 of the AIP?	No

Table 4.2 Has the proponent:

	AIP requirement	Proponent response
1	Describe the water source(s) the activity will take water from?	The Quarry is located within the Hunter River catchment in the Hunter Regulated River Alluvial Water Source which is a water source covered by the Hunter Unregulated and Alluvial Water Sources 2009 WSP
2	Predicted the total amount of water that will be taken from each connected groundwater or surface water source on an annual basis as a result of the activity?	See Section 3.3.
3	Predicted the total amount of water that will be taken from each connected groundwater or surface water source after closure of the activity?	Nil. No quarry voids will remain post closure. See Section 3.2.3.
4	Made these predictions in accordance with Section 3.2.3 of the AIP?	Baseline site groundwater conditions have not been established however these conditions have been inferred based on the long-term upstream and downstream monitoring records of groundwater bores and river gauging stations. The assessment has been based on 3D numerical modelling. The predictions are made in accordance with all other requirements of Section 3.2.3 of the AIP.
5	Described how and in what proportions this take will be assigned to the affected aquifers and connected water sources?	See Section 3.3.
6	Described how any licence exemptions might apply?	No licence exemptions apply.
7	Described the characteristics of the water requirements?	Groundwater will be directly intercepted by the quarry pits, and this will indirectly influence the adjacent Hunter River. Refer to the surface water assessment for the detailed components of the site water balance.
8	Determined if there are sufficient water entitlements and water allocations that are able to be obtained for the activity?	Refer to the surface water assessment for the current water entitlements. The proponent commits to obtaining sufficient water entitlements and water allocations prior to operations.
9	Considered the rules of the relevant water sharing plan and if it can meet these rules?	The WSPs allow for access and trading for take of groundwater. These licenses can be purchased from the market and the project can meet the rules of the relevant WSP's.
10	Determined how it will obtain the required water?	Water is lost via evaporation from the quarry pits and via direct take.
11	Considered the effect that activation of existing entitlement may have on future available water determinations?	The proposed take of water (and method) is consistent with the current approved operations. Consideration has not been made on the availability of future water determinations.

	AIP requirement	Proponent response
12	Considered actions required both during and post-closure to minimise the risk of inflows to a mine void as a result of flooding?	No quarry voids will remain post closure. See surface water assessment for comment on flooding.
13	Developed a strategy to account for any water taken beyond the life of the operations of the project?	The proponent has committed to rehabilitating the site to a minimum of two metres of cover above the top of the aquifer across the site. Therefore, there will be no final void intercepting aquifers at the project site, and groundwater take will not extent beyond the life of operation of the project.
	Will uncertainty in the predicted inflows have a significant impact on the environment of other authorised water users? **If YES, items 14 – 16 must be addressed.**	The predicted drawdown is limited to within the extent of the project area. As such there will be no impact to other authorised water users.
14	Considered any potential for causing or enhancing hydraulic connections, and quantified the risk?	N/A
15	Quantified any other uncertainties in the groundwater or surface water impact modelling conducted for the activity?	N/A
16	Considered strategies for monitoring actual and reassessing any predicted take of water throughout the life of the project, and how these requirements will be accounted for?	Monitoring is proposed as part of project conditions and this data will feed into future surface water and groundwater model predictions. See Section 5.

Table 4.3 Determining water predictions in accordance with Section 3.2.3.

	AIP requirement	Proponent response
1	**For the Gateway process**, is the estimate based on a simple modelling platform, using suitable baseline data, that is, fit-for-purpose?	N/A
2	**For State Significant Development or mining or coal seam gas production**, is the estimate based on a complex modelling platform that is: • Calibrated against suitable baseline data, and in the case of a reliable water source, over at least two years? • Consistent with the Australian Modelling Guidelines? • Independently reviewed, robust and reliable, and deemed fit-for-purpose?	The estimate was developed using the MODFLOW-USG modelling code – a complex modelling platform widely used for groundwater modelling. The predictions were calibrated against the available regional baseline data. No site-specific groundwater data was available. The groundwater model was developed in accordance with the practices outlined in the Australian Modelling Guidelines. To date, no independent review has been conducted of the groundwater model. Internal peer review was carried out during the development of the groundwater model. The model calibration statistics indicate that the groundwater model is robust and reliable. The groundwater model is considered a Class 1 model under the Australian Modelling Guidelines, and is considered fit-for-purpose to determine the impact of a low-risk development.
3	In all other processes, estimate based on a desk-top analysis that is: • Developed using the available baseline data that has been collected at an appropriate frequency and scale; and • Fit-for-purpose?	N/A

Table 4.4 Has the proponent provided details on:

	AIP requirement	Proponent response
1	Establishment of baseline groundwater conditions?	No. However it is conceptualised, based on the long-term upstream and downstream monitoring records of groundwater bores and river gauging stations, that groundwater conditions in the alluvium are governed predominantly by levels in the Hunter River. On this basis the model assumes a direct and local connection between the river and the alluvial water source.
2	A strategy for complying with any water access rules?	The proponent will consult with the regulator to ensure compliance with the requirements of the relevant WSPs.
3	Potential water level, quality or pressure drawdown impacts on nearby basic landholder rights water users?	The predicted drawdown is limited to within the extent of the project area. No private bores are predicted to be impacted due to the project. As such there will be no impact to other authorised water users.
4	Potential water level, quality or pressure drawdown impacts on nearby licenced water uses in connected groundwater and surface water sources?	The predicted drawdown is limited to within the extent of the project area. No private bores are predicted to be impacted due to the project. As such there will be no impact to other authorised water users.
5	Potential water level, quality or pressure drawdown impacts on groundwater dependent ecosystems?	The risk of drawdown at identified ecosystems potentially dependent on groundwater is discussed in Section 3.3.
6	Potential for increased saline or contaminated water inflows to aquifers and highly connected river systems?	The method of proposed quarrying is consistent with the current and approved operations. There has been no increase in salinity or contamination as part of existing operations.
7	Potential to cause or enhance hydraulic connection between aquifers?	The project is not predicted to cause enhanced hydraulic connection between aquifers.
8	Potential for river bank instability, or high wall instability or failure to occur?	Refer to the surface water assessment for comment on the potential for river bank instability or failure.
9	Details of the method for disposing of extracted activities (for coal seam gas activities?)	N/A

Table 4.5 Minimal impact considerations.

Aquifer – Alluvial aquifer	
Category – Highly productive	
Level 1 minimal impact consideration	**Assessment**
Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climactic post-water sharing plan variations, 40 m from any: • high priority groundwater dependent ecosystem or • high priority culturally significant site listed in the schedule of the relevant water sharing plan.	No high priority GDEs or culturally significant sites listed in the WSP for the Hunter Unregulated and Alluvial Water Sources are within the predicted drawdown extent of the project (see Section 3.3).
OR A maximum of a 2 m water table decline cumulatively at any water supply work.	The maximum predicted drawdown at any water supply work is less than 2 m (see Section 3.3).
Water pressure A cumulative pressure head decline of not more than 40% of the post-water sharing plan pressure head above the base of the water source to a maximum of a 2 m decline, at any water supply work.	The maximum predicted drawdown at any water supply work is less than 2 m (see Section 3.3).

Aquifer – Alluvial aquifer	
Category – Highly productive	
Level 1 minimal impact consideration	**Assessment**
OR, for the Lower Murrumbidgee Deep Groundwater Source: A cumulative pressure head decline of not more than 40% of the post-water sharing plan pressure head above the top of the relevant aquifer to a maximum of a 3 m decline, at any water supply work.	
Water quality	
Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.	No change to the groundwater quality is predicted.
No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity.	No change to the groundwater salinity is predicted.
No mining activity to be below the natural ground surface within 200 m laterally from the top of high bank or 100 m vertically beneath (or the three-dimensional extent of the alluvial water source – whichever of these is the lesser distance) of a highly connected surface water source that is defined as a reliable water supply.	No quarrying activities will occur within 200 m of the high bank of the Hunter River, or occur at a depth of greater than 100 m.
Not more than 10% cumulatively of the three-dimensional extent of the alluvial material in this water source to be excavated by mining activities beyond 200 m laterally from the top of high bank and 100 m vertically beneath a highly connected surface water source that is defined as a reliable water supply.	Quarrying activity outside 200 m of the high bank of the Hunter River, and at a depth of greater than 100 m will not remove more than 10% cumulatively of the alluvial material.

5. Groundwater monitoring program

Post approval, the proponent commits to developing a water management plan that follows the Guidelines for Groundwater Documentation for NSW Major Projects. This water management plan will include the construction and placement of new monitoring bores, frequency of monitoring, water quality analysis suites and a trigger action response plan.

As part of the water management plan, the proponent commits to installing a site-specific groundwater monitoring network at the project site. This groundwater monitoring network would be installed within the Hunter River alluvium to assess the groundwater level and quality characteristics prior to, and during operations. A proposed groundwater monitoring network is shown in Figure 5.1 and summarised in Table 5.1. The groundwater monitoring network will consider upgradient and downgradient flow conditions and will include monitoring bores adjacent to the Hunter River to confirm the groundwater and surface water interaction that is likely to occur at the project site. All monitoring bores will be drilled and installed within the Hunter River alluvium.

The groundwater monitoring network should be installed with a series of groundwater level and salinity loggers to monitor groundwater levels and salinity at a frequency of every 6 hours. This data will assist in monitoring the local groundwater flow and chemistry conditions at the site. Should any groundwater monitoring bore be removed or disturbed due to quarry development, a suitable replacement bore should be installed.

The water management plan will also include provisions for the monitoring of surface waters on-site. The water elevation in any quarry excavation will also need to be monitored to understand the relationship between the pit level(s) and the surrounding groundwater levels. Any transfer of water around the site (via pumping) will need to be captured via suitably calibrated and installed flowmeters. This transfer of water will enable calibration of the site water balance model.

The above data will be used annually to update the existing numerical groundwater model. The model will be updated to include a transient calibration and will be used to forward predict the take of water to ensure sufficient entitlement is held by the proponent. Performance against the water management plan will be reported annually and will include any numerical model outputs regarding water take.

Figure 5.1 Proposed groundwater monitoring network

Table 5.1 Proposed monitoring bore locations (GDA94, Z56)

Bore_ID	Easting	Northing
1	285092	6407343
2	285006	6406750
3	286366	6407278
4	286529	6407125
5	285814	6407448
6	285891	6406829
7	286037	6406674
8	285514	6406603

6. Water access licences

The proponent is committed to having the necessary Water access licences (WAL) for the respective Water Sharing Plans in place prior to operations. These WALs will account for the maximum predicted take for each water source.

The proponent is also committed to having the relevant nomination of work dealing applications for WALs proposed to account for water take by the project.

In summary, the proponent is committed to undertaking the proposal in accordance with appropriate legislation and regulations. The necessary licences would be applied for to account for the take of water.

7. References

Barnett, B.; Townley, L.R.; Post, V.; Hunt, L.; Peeters, L.; Richardson, S.; Werner, A.D.; Knapton, A. and Boronkay, A., 2012. Australian Groundwater Modelling Guidelines. National Water Commission. Canberra.

Umwelt (Australia) Pty Limited. 2020. Dalswinton Quarry Expansion. Surface Water Impact Assessment. Report No. 4397/R01.