# Advice to decision maker on coal mining project

## IESC 2018-096: Olive Downs Project (EPBC 2017/7867 – Olive Downs Project Mine Site and Access Road, 2017/7868 – Olive Downs Project Water Pipeline, 2017/7869 – Olive Downs Project Electricity Transmission Line, 2017/7870 – Olive Downs Project Rail Spur)

## – New Development

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| Requesting agencies | The Australian Government Department of the Environment and Energy  The Queensland Office of the Coordinator-General |
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| Advice stage | Assessment |

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| The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the IESC) provides independent, expert, scientific advice to the Australian and state government regulators on the potential impacts of coal seam gas and large coal mining proposals on water resources. The advice is designed to ensure that decisions by regulators on coal seam gas or large coal mining developments are informed by the best available science.  The IESC was requested by the Australian Government Department of the Environment and Energy and the Queensland Office of the Coordinator-General to provide advice on Pembroke Olive Downs Pty Ltd’s Olive Downs Project in Queensland. This document provides the IESC’s advice in response to the requesting agencies’ questions. These questions are directed at matters specific to the project to be considered during the requesting agencies’assessment process. This advice draws upon the available assessment documentation, data and methodologies, together with the expert deliberations of the IESC, and is assessed against the IESC Information Guidelines (IESC, 2018). |

### Summary

The Olive Downs project is a proposed new coking coal mine with associated infrastructure in Queensland. This large-scale project will have a disturbance area of over 16 000 ha and a planned extraction rate of up to 20 Mtpa for an operational life of 79 years.

**Key potential impacts** from this project are:

* loss of 120 ha of wetlands through direct removal, including removal or modification of seven wetlands in the project area defined in Queensland as being of High Ecological Significance;
* increased erosion potential and reduced floodplain habitat from constriction of the floodplain as a result of placement of two final voids on the (existing) floodplain;
* impacts to the flow regime and water quality in the Isaac River from untreated discharges and groundwater drawdown;
* impacts to groundwater-dependent wetlands and terrestrial vegetation from groundwater drawdown;
* removal of aquatic and riparian habitat (40–60 m wide) at three places along the Isaac River, disrupting movement corridors for State and Commonwealth-listed species (e.g. Greater Gliders *Petauroides volans*) and other biota;
* loss of habitat connectivity, and potentially downstream impacts to water quality, during and for some time after the diversion of Ripstone Creek;
* impacts to groundwater users from lowered water levels; and
* cumulative impacts on surface water, groundwater and terrestrial and aquatic ecosystems from mining in the region.

In general, the information in the different sections of the draft Environmental Impact Statement (EIS) is clearly presented, but it needs to be better integrated to aid consideration of potential impacts. There are several areas in which additional information is required to aid risk assessment, and other areas in which information could be improved over time to facilitate management. In some areas, the limited spatial and temporal extent of the baseline data, particularly for ecology and groundwater, makes it difficult to infer whether there may be additional risks. The IESC also suggests additional avoidance and mitigation measures would improve environmental outcomes.

The IESC has identified key areas in which additional information is required. To address these, the proponent should:

* undertake additional baseline ecological surveys. The small ecological survey effort described in the EIS, relative to the size of the project, and the limited time-series data available means that there is a strong potential for listed and rare species to be present but not yet recorded;
* update the numerical groundwater modelling once additional data have been collected. Confidence in the conclusions drawn about groundwater drawdown impacts is severely constrained by a paucity of relevant data, and this limitation is not offset by the adopted level of modelling complexity;
* provide additional information on the predicted quality of untreated discharge water and associated impacts of both intentional and unintentional releases. The IESC acknowledges the apparent intent to provide this information as part of the Receiving Environment Management Plan;
* undertake further assessment of groundwater-dependent ecosystems beyond the area of direct clearing to determine their location, condition and vulnerability to projected groundwater drawdown;
* consider avoidance and further mitigation measures for the proposed 2‑km diversion of Ripstone Creek;
* update surface water modelling to address deficiencies identified in this advice. In the modelling presented, little use has been made of local streamflow gauging information. This reduces confidence in the accuracy of and impact estimates relating to maximum flood levels, erosivity, performance of the diversion channel, and the assessed changes to the flow regime on the long-term viability of riparian vegetation and its recruitment. Modelling should be updated to inform detailed landform planning, particularly on the floodplain and the proposed diversion channel;
* provide a trigger action response plan (TARP) as part of the Water Management Plan that outlines effective mitigation actions to be taken when there is a suspected exceedance of a trigger value;
* provide information on relevant recent regional impacts to Queensland and Commonwealth-listed species and to wetlands, and an assessment of the cumulative potential impacts to the Isaac River from nearby mining activities. This would enable a more robust assessment of cumulative impacts to surface water resources and listed species and water-dependent communities and ecosystems from the present proposal; and
* consider further avoidance and mitigation options for the two final voids proposed to be placed on the Isaac River’s floodplain. The risks could be avoided by revising mine plans to avoid placing voids on the floodplain. The risks could be partially mitigated by partial backfilling to above the water table or to above the elevation of saline aquifers.

**Context**

The Olive Downs Project is a proposal to develop a new coking coal mine and associated infrastructure approximately 40 km south-east of Moranbah, Queensland. The proposed project is located in the Bowen Basin, within the catchment of the Isaac River, in the Fitzroy River Basin. The disturbance footprint of the project is approximately 16 300 ha, within a referral area of 25 300 ha. The project will produce up to 20 Mtpa of run-of-mine coal for a planned operational life of 79 years.

Open-cut mining is to occur in two domains: the Olive Downs South domain to the north and the Willunga domain to the south. The two domains will be connected by an overland coal conveyor over the Isaac River.

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) assessment, the project, as considered in this advice and assessment documentation, consists of four referrals covering the mine and associated infrastructure:

* EPBC 2017/7867 – Olive Downs Project Mine Site and Access Road
* 2017/7868 – Olive Downs Project Water Pipeline
* 2017/7869 – Olive Downs Project Electricity Transmission Line
* 2017/7870 – Olive Downs Project Rail Spur

The main potential impacts to water resources from the overall project relate to the mine. The IESC notes that a section of the rail spur and water pipeline run in the floodplain of the Isaac River. Provided that construction and operation of this infrastructure follows recognised standards, there is unlikely to be a material impact on the Isaac River.

In general, the information in the draft EIS is clearly presented, which aids in consideration of potential impacts. In some areas, the EIS includes more thorough investigations than are commonly seen in EISs, for example the resistivity survey to investigate shallow aquifers, the geomorphology assessment, and the inclusion of faults and neighbouring mines in the numerical groundwater model. Such investigations reduce uncertainty in the assessment. However, there is room to improve integration of the discrete components of the EIS. For example, the statements about the likely distribution of GDEs in Appendices A, B and C are not consistent with statements about distribution of GDEs in Appendix D. This results in ambiguity about the distribution of GDEs in the study area and how changes in drawdown and surface/groundwater interactions may impact these GDEs.

**Response to questions**

The IESC’s advice, in response to the requesting agencies’ specific questions, is provided below.

Question 1: Advice is sought on whether the proponent, using the information in the draft EIS (including baseline data), has adequately identified and assessed the key risks and impacts to surface and groundwater resources? If not, what additional information would assist in the identification and assessment of impacts to water resource?

1. The proponent has generally presented appropriate information to understand and assess the key risks~~.~~ Further information should be provided, as discussed below.

Groundwater

1. Adequacy of the information presented for groundwater and advice on collection of additional information are discussed in the context of groundwater modelling in response to Question 2.

#### Surface Water

1. The proponent has provided engineering design considerations for the diversion on Ripstone Creek but has not provided detailed geomorphological or vegetation design information. The IESC provides comment in response to Questions 3 and 4 on mitigation measures that should be included when undertaking a more detailed design.
2. The proponent has provided little information on the predicted quality of discharge water, both intentional and unintentional releases. Given that the proponent noted exceedances of Water Quality Objectives for a range of parameters (see Paragraph 28), this information should be provided, together with an assessment of the likely impacts. This information would be expected to form part of the Receiving Environment Management Plan, which has not yet been prepared.
3. The IESC commends the use of stochastic procedures to help assess the water management risks involved in operating the mine over different periods. While such approaches are well suited to characterising the bounds of the risks involved, there is some concern that the stochastic climate sequences (and hence estimates of inflows) are overestimated compared to observed data. This issue is further discussed below (Paragraph 19).
4. The IESC also acknowledges the effort that the proponent has taken to ensure that the adopted methodology is consistent with the new national guidelines (Ball et al. 2016). However, while the large-scale estimates for the regional flood event model make good use of the available gauging and design information, little or no use appears to have been made of the eight other streamflow gauges in the local area. The upstream areas reporting to these gauges are of a similar size as the creeks near the Olive Downs Coking Coal Project Area and would provide valuable information on how flood peaks scale with area. Further comment on this is provided in response to Question 2.

#### Ecology

1. The information provided on wetlands within the project area is not clearly presented. The proponent does identify Regional Ecosystems that intersect wetlands. However, the proponent should also provide more details about each wetland type (for example, following the ANAE classification, Aquatic Ecosystems Task Group 2012).
   1. The IESC notes that wetlands have been considered in the assessment as a matter of state but not national environmental significance. The “water trigger” of *the Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) protects water resources, which includes wetlands. The proponent should include wetlands in their assessment of impacts to Matters of National Environmental Significance (MNES).
   2. The proponent should identify how they will compensate for the removal of wetlands, including seven of High Ecological Significance, through environmental offsets.
2. There is a lack of consistency in the evaluation of groundwater-dependent ecosystems (GDEs) between the proponent’s ecological assessments and the groundwater modelling. The ecological assessment would be improved if it took account of the results of the groundwater report, including the potential for upwelling of groundwater in some areas discussed in the resistivity survey report. Additionally, the proponent does not provide evidence for their conclusion that riparian and floodplain terrestrial vegetation is unlikely to be groundwater-dependent (see Paragraph 15). This issue is discussed further in response to Questions 3 and 4.
3. The small ecological survey effort means that it is not possible to confirm or refute the presence of rare and endangered species. Relative to the size of the project, and considering the limited time-series available, this means that there is a strong potential for listed and rare species to be present but not yet recorded. For example, only two monitoring bores were sampled for stygofauna and only sampled once. Although the proponent notes this sample size is probably insufficient, it is not clear whether further sampling of this obligate GDE is intended.
4. The proponent has not undertaken a surface water assessment of potential impacts to the 76 wetlands in the project area (EIS, App. C, p. iii). Such wetlands are part of the regional mosaic of wetlands across this landscape and together form a broader ecosystem. The proponent should provide an assessment of how changes to surface hydrology will affect the biota and ecological processes in remaining wetlands and how removal or modification of wetlands in the project area will affect ecological connectivity.
   1. These wetlands are also likely to provide broader regional water quality benefits. Their removal may impact on downstream water resources.
   2. Wetlands, and other depressions in the landscape, can often be points of enhanced recharge or areas of groundwater interaction and hence their removal may impact on water levels and quality in the groundwater systems.

Final Landform

1. The proponent has not examined the potential for hydraulic loading from out-of-pit waste rock dumps to change the groundwater regime. The implications of processes associated with hydraulic loading for vegetation and landform stability should be examined. This issue is raised in the groundwater assessment (EIS, App. D, p. 103) but is not further examined or modelled.
2. The proponent raises the possibility of localised interaction between alluvial groundwater and recovered groundwater within part of final void ODS1, *Olive Downs South void 1* (EIS, App. D, p. 97). Potential implications of this interaction for the groundwater regime and water quality are not discussed in the groundwater reports. The long-term environmental implications of this should also be assessed and accounted for in the final landform design.

Question 2: Advice is sought on whether the numerical and conceptual modelling provided is adequate for a project of this type and at this stage of development to assess the project's impacts? What refinements, if any, does the IESC recommend should be made to the modelling?

#### Groundwater Modelling

1. The numerical groundwater modelling and the conceptual model on which it is based are generally of a high standard and suitable for this type of project and stage of assessment. The uncertainty analysis employs state-of-the-art methods. The IESC notes the limitations inherent in the data available. However, there are potential improvements in initial model calibration and in the application of uncertainty methods that should be considered, especially as additional data are collected. In particular:
   1. the data available for calibration are sparse compared to the size of the modelled area and the scale of proposed operations. The groundwater head data available for calibration are poorly distributed over the modelled area and there is only a short period with a good time-series. There is poor spatial coverage data on hydraulic conductivity values. Recharge and specific yield and storage are poorly constrained. This lack of data reduces confidence in model calibration and hence predictions;
   2. given the paucity of data for conceptualisation, calibration and to inform natural variability in system and model parameters and model structure/conceptualisation, it is not clear whether the uncertainty analysis has explored the full range of plausible parameter values and conceptualisations (see comment below on fault parameterisation). The presented uncertainty analysis may therefore underestimate uncertainty;
   3. the proponent describes faults as having mixed behaviour – potentially acting as conduits or barriers to groundwater flow. Given that there are indications (particularly resistivity results) that faults in the project area may act as flow conduits, it would be valuable to see higher hydraulic conductivity values (at least an order of magnitude greater than the currently modelled range) explored in the sensitivity (or uncertainty) analysis. This should be informed by additional field-based hydrogeological characterisation of faults and associated damage zones;
   4. the Monte Carlo simulation was limited to assessment of uncertainty in of hydraulic conductivity and specific yield. Recharge was not part of this analysis; and
   5. it is not clear how the available evidence has been used to select and parameterise the governing distributions used in the Monte Carlo analyses, nor how such evidence was used to support the number and distribution of the adopted pilot points. It is also not clear what criteria were used to reject the large proportion (33%) of selected simulations from the results. As such, it is difficult to ascertain whether the distribution of results provide a representative estimate of the actual uncertainty involved.
2. These issues could be addressed by collecting more data and using them in model conceptualisation, calibration and uncertainty analysis that explores a wider parameter range and model conceptualisation (including faults). Until this is provided, the IESC considers that the uncertainty bounds for drawdown predictions should be interpreted with caution.
3. In the groundwater report (EIS, App. D), it is concluded that riparian and terrestrial vegetation is unlikely to be dependent on groundwater, given the depth to groundwater of 10–17 m and the ephemeral nature of watercourses. The IESC notes that many Australian tree species can access groundwater within and substantially below this depth range. Notably, Poplar Box (*Eucalyptus populnea*), present on alluvium in some of the project area, has been shown to access groundwater to depths of up to 26.6 m (Kath et al. 2014), which is beyond measured groundwater depth in the project area. Further, the proponent suggests that palustrine wetlands and associated vegetation may be dependent on perched aquifers that are unlikely to be connected to the deeper groundwater system (EIS, App. D).
   1. The location of bores used to determine the likely depth to groundwater at particular sites (e.g. individual wetlands) has not been reported in the groundwater report so it cannot be determined if these bores are located close enough to the wetlands for conclusions on surface water-groundwater connectivity and interactions to be robust. This information should be provided.
   2. The proponent infers the depth to the watertable across the site from the 18 monitoring bores located in the alluvium and regolith. From Figure 5-1 (EIS, App. D, p. 46), it appears that only four of these bores are located outside the northeast corner of the Olive Downs South (ODS) domain. Any assumptions on depth to groundwater based on these bores are unlikely to be robust across the site and additional bores are needed to provide stronger evidence to support the proponent’s conclusion that there are few if any Type 2 or type 3 GDEs (according to Richardson et al. 2011) within the project area.
4. To adequately capture information from areas of potential drawdown, additional nested bores targeting all aquifers should be installed:
   1. near the western satellite pit in the ODS domain (ODS 9);
   2. in the vicinity of wetlands that may be subject to groundwater drawdown; and
   3. beyond the project area both within the predicted impact zone and just beyond the predicted drawdown extent to confirm drawdown predictions. These are needed so that the spatial extent of drawdown can be monitored and the groundwater model validated. Given the number of nearby mines, a co-ordinated approach to monitoring and data sharing among operators should be considered to increase the efficiency of sampling and monitoring effort and to provide optimal spatial and temporal coverage, especially in off-lease areas. This would provide more reliable information on potential cumulative effects. These data should then be incorporated into future iterations of the groundwater model.
5. The proponent could make better use of information on potential inter-aquifer connectivity from the transient electromagnetic (TEM) resistivity survey. The resistivity study (Attachment A4 of App. A of App. D) indicates areas in which the shallow aquifer may be connected to deeper groundwater. This is supported by hydrographs presented for this project in some locations. The presented conceptualisation does not include this inter-aquifer connectivity; however, it does not appear that the model has been constrained to preclude inter-aquifer connectivity, so this may not affect modelling results. This needs to be confirmed. The proponent should use resistivity survey data to:
   1. constrain hydrogeological parameterisation as part of the next model update;
   2. target future investigative work. This should include the installation of new nested monitoring bores at the locations identified by the resistivity study as potential sites for inter-aquifer connectivity, to confirm the results of the resistivity study. The sensitivity of the resistivity data (e.g. during the inversion process) to alternative interpretations of lithology and/or pore fluid conductivity could be further explored. The hydrogeological conceptualisation of the project site should be reviewed when these data become available and the numerical groundwater model updated accordingly; and
   3. help conceptualise the interaction between surface water and groundwater. Fine-scale geophysical investigations along stream beds would provide additional valuable information to better constrain this surface water-groundwater interaction.
6. Once additional data have been collected, the numerical groundwater model should be reviewed and updated. Although the proponent proposes 5-yearly reviews, the IESC considers that the model should be updated initially after a shorter interval, such as two years after installation of additional monitoring bores. If significant deviation is identified (based on pre-defined statistically robust criteria), then the model should be recalibrated and impact predictions revised. During this process, consideration should be given to how the observed impacts correlate with the uncertainty analysis results, where applicable, and to refine the hydrogeological conceptualisation if needed. In the meantime, the monitoring data should be compared every three to six months with model predictions. If it appears that impacts are considerably greater than currently predicted, consideration should be given to commencing the full model review sooner. If observations and model predictions are comparable, then the time between model reviews may be able to be extended.

#### Surface Water Modelling

1. The natural inputs to the mine water management system are based on an Australian Water Balance Model (AWBM) (which has been calibrated to only one catchment of the Isaac River) and the use of stochastic rainfall replicates. It is concerning that the median observed annual rainfalls coincide with the lower (90%) bound of the synthetic series (Figure 5.8, Appendix E), which suggests that the typical annual synthetic inflows are biased high. However, this “high bias” would be partially offset by the underestimation of streamflows obtained using the AWBM model (Figure 7.5, Appendix E). Overall, it is possible that the water usage requirements associated with the predicted 10% (dry) climatic conditions are representative of the likely future typical (50%) requirements, without allowing for climate change. For example, the external makeup requirements associated with a 10% probability of exceedance might be better regarded as being associated with median climatic conditions. If this is of critical concern, then the efficacy of the stochastic rainfall replicates should be revised to be more consistent with local observations.
2. The water management requirements are based partly on groundwater inflows provided by SLR Consulting, which do not appear to be related to the groundwater modelling as described in Appendix D by Hydro Simulations. The degree to which these groundwater inflow estimates are consistent between the two studies needs to be clarified. While this is not likely to make a material difference on final water levels, it may have implications for the timing of maximum salinity levels in the voids, and the quality of controlled and uncontrolled discharges. The IESC considers that the issue should be addressed before finalisation of the Receiving Environment Management Plan
3. The configuration of the regional flood event model is well suited to characterising flood risk at the larger scales of interest, and an excellent level of agreement has been achieved between model and observed characteristics at the Deverill gauging station. However:
   1. it is unclear why the proponent did not make use of stream flow records from the nearest gauge on Isaac River (at Deverill) in their flood event modelling to calculate design runoff. This should either be explained, or the modelling should be revised to make use of these data;
   2. in the regional flood event model, it is noted that there are only two or three model sub-areas upstream of the locations relevant to the other creeks near the Olive Downs Coking Coal Project area. While the adoption of approximately equal sub-areas in the flood event is generally to be preferred, in this application it presents two problems: first, the number of sub-areas upstream of these locations is probably insufficient to adequately characterise the storage routing characteristics in the local catchments, and second, these catchments are over an order of magnitude smaller than the scale at which the model has been verified;
   3. the development of individual flood event models are based on regional routing parameters and thus do not make good use of the information contained in the calibrated large-scale model. There is in general a factor of two difference between the local and regional model estimates, which does not provide good confidence in either set of estimates of flood risk; and
   4. in addition to the difference in the estimates derived using the regional- and local-scale models, the IESC notes that the relationship between sub-catchment area and flood peaks does not vary in a manner consistent with physical reasoning. In order to reconcile the difference between the different model estimates and improve confidence in the estimates, it is suggested that additional information be compiled on how flood magnitude varies with catchment area. This is best undertaken using flood frequency quantiles derived from nearby gauging stations. Information from RFFE model estimates would also be helpful.
4. It is not entirely clear how the temporal pattern ensembles have been used. While it is appropriate to adopt a single representative temporal pattern to derive inputs to the TUFLOW model, the peaks of such hydrographs should be scaled to match the average peak obtained from the flood event model ensembles based on approximately ten temporal patterns.

Question 3: What does the Committee consider are the key risks and impacts of the project to water resources and water-related assets?

Question 4: Advice is sought on whether the proposed monitoring, mitigation and management measures are adequate to identify, mitigate and manage impacts to water resources? If not, what additional measures does the IESC consider are required to monitor, mitigate and manage impacts to water resources?

1. Responses to Questions 3 and 4 are grouped below to avoid repetition.
2. While the communication of risks in the various sections of the EIS is generally clear, the preliminary risk assessment included in the EIS (App. O) does not adequately summarise these risks. Inclusion of all key environmental risks in the risk assessment would aid understanding and communication of the project’s risks to the environment, including cumulative risks (see response to Question 5).

#### Groundwater

1. The IESC has described concerns with the current groundwater data and numerical modelling in response to Question 2. There is a lack of empirical data on GDEs relative to the size of the project. Further discussion of potential impacts to GDEs from groundwater drawdown was discussed in response to Question 1 and further discussion is provided under the Ecology section below.
2. Groundwater drawdown is predicted to impact five private bores, although the uncertainty analysis shows that this could vary from five (very likely – 90%) to ten (very unlikely – 10%). The proponent would address these impacts through make-good arrangements.
3. Several areas that the proponent describes as being areas of potential GDEs are predicted to experience groundwater drawdown (Figures 5-27 and 5-28, EIS, App. D, pp. 73-74; Figure 6-3, EIS, App. D, p. 88). The locations are:
   1. to the north of the Olive Downs South domain, where drawdown of approximately 2 m is predicted;
   2. to the east of the Olive Downs South domain, where 1–10 m of drawdown is predicted;
   3. immediately south of the Olive Downs South domain, adjacent to Ripstone Creek, where 10–20 m of drawdown is predicted; and,
   4. along Boomerang Creek, to the south and southwest of the Olive Downs South domain, where 10 m of drawdown is predicted.
4. Both alluvial and regolith groundwater quality was determined on three occasions only (Oct, 2017, Dec 2017 and Feb 2018). Given that exceedances of aquatic ecosystem protection guidelines for a range of total and dissolved metals (including Cd, Cu, Pb, Mn, Ni, Zn, B and Cr) were found, further baseline monitoring is required to improve temporal coverage and to derive site-specific guideline values. The IESC notes that the Queensland Government has provided water quality objectives for a number of parameters for rivers in the Fitzroy Basin (State of Queensland 2011). These may assist in providing default guideline values for the project until suitable local data are collected. The IESC notes that groundwater quality monitoring is proposed to be quarterly. This is likely to be suitable for most sites. It may be helpful to identify a subsample of sites that could be monitored more frequently such as some bores located close to waste rock dumps to monitor for seepage.
5. The proponent proposes to produce a Water Management Plan, which should outline monitoring required to derive site-specific guideline values for groundwater quality. The IESC considers that a trigger action response plan (TARP) should be developed as part of the Water Management Plan. This plan must outline effective mitigation actions that will be taken when there is a suspected exceedance of a guideline value. As discussed in response to Question 2, the IESC considers that additional bores should be installed. These should also be monitored for groundwater quality.
   1. Water-level guideline values should be developed for the additional bores required beyond the project site as discussed above (Paragraph 16c).
   2. All guideline values should be derived from data collected prior to the project commencing. At least 24 consecutive monthly samples should be used. Consideration should be given to developing wet- and dry-season guideline values.
   3. Quality assurance and quality control measures (e.g. duplicates, blanks etc.) should be used during sampling and not just during the data entry stage as currently proposed (EIS, App. D, p. 111).
   4. Monitoring data and reports should be provided to the regulator and made available promptly to the public via the company/mine website.

#### Surface Water

1. The project will increase flood depths, sheer stress on sediments and stream power in the Isaac River (EIS App. F). Increases in flood depths on the majority of private properties (other than those owned by the mine) are predicted to be small. It is noted in the geomorphology report (EIS, App. B of App. E, p. 80) that shear stresses from the proposed project would only be acceptable (to limit impacts from river bed and bank erosion) if vegetation is retained along the watercourses. For a 2% annual exceedance probability (AEP) event, shear stresses on the west bank of the Isaac River will increase by up to 50 N/m2 (EIS, App. F, p. 82).
   1. Given this risk to channel stability, the proponent needs to assess the impacts of the potential changes to the flow regime on the long-term viability of riparian vegetation and its recruitment (e.g. seedset, establishment and survival of seedlings), particularly where shear stresses and stream power is greatest. This will be particularly important given the long timeframe of the proposed project and the fact that the 2% AEP velocities for the final landform are, in the vicinity of Deverill, up to 1.5 m/s higher than the existing (undeveloped) flow velocities (EIS, App. D of App. F, map 6). The flood and flow modelling predicts that this risk is likely to be greatest in the north of the project area where the floodplain is constricted between two proposed levees.
   2. If this analysis shows that vegetation will not adequately protect the Isaac River from erosion, the proponent will need to modify the design or implement additional effective mitigation measures. The IESC considers that any mitigation measures should not require ongoing maintenance, given the proposed alteration to flood dynamics is permanent.
2. The proponent proposes to discharge 90 to 890 ML/a under median climatic conditions, with releases of up to 2140 ML/a under wet conditions (10th percentile) (EIS, App. E, p. 124). This will alter the flow regime in the Isaac River. The proponent has not yet developed a Receiving Environment Management Plan – this should provide more detail of predicted impacts and should include the additional information for inclusion in the plan noted previously in this advice (Paragraphs 4, 20). The proponent does not propose to treat water prior to discharge, other than through sedimentation ponds. The proponent does not propose water quality limits for discharge water other than for electrical conductivity.
   1. The IESC considers that water quality guideline values should be set such that water quality objectives are protected for all relevant parameters, especially given the elevated concentrations of several metals in groundwater (especially copper, manganese and iron) and in leach testing (aluminium, arsenic and selenium). This may necessitate treatment of water prior to discharge.
3. Groundwater drawdown from the project is predicted to reduce the groundwater contribution to flow in the Isaac River. While discharge of untreated mine water will add flow to the river over the course of a year, the timing of flow is likely to change, which may have ecological repercussions (discussed under the Ecology section below).
4. The project will impact on Ripstone Creek, a tributary of Isaac River, by diverting a section of the creek and by reducing the catchment area.
   1. The diversion will consist of the removal of 2140 m from the current creek, replacing it with 1888 m of diversion.
   2. The project will reduce the catchment area of Ripstone Creek by approximately 13% during mining. Post-mining, the reduction in catchment area is less, at approximately 7% (EIS, App. E).
5. The IESC notes that the section of Ripstone Creek that is to be diverted is in a corner of the disturbance area. Consideration should be given to avoiding the area and the need for the diversion.
6. The IESC also notes that the proponent plans a coal conveyor over the Isaac River. It is important that this is appropriately designed and managed to avoid coal dust or other material entering the river or the riparian zone.

#### Ecology

1. The proposed project will directly remove approximately 120 ha of wetland regional ecosystems (swamps and lakes), including 61 ha of wetlands of High Ecological Significance (EIS, App. A, p. iii; EIS, App. C, p. 154) and 1449.5 ha of native vegetation on alluvium and 82.5 ha of riparian vegetation (EIS, App. A, pp. 49, 118), which are stated in the ecological assessments to be at least partly groundwater-dependent (EIS, App. A and App. C).
2. A 2140­‑m section of Ripstone Creek, along with its riparian corridor, will be removed by mining in the Olive Downs South Satellite Pit and replaced with a 1888-m diversion southwest of the pit. Potential impacts of this diversion include altered flow regime (e.g. altered seepage into the constructed riverbed and banks), loss of instream habitat heterogeneity and disrupted continuity of the riparian corridor until vegetation is re-established along the diverted section. The proponent has outlined their approach to ecological monitoring, but has not yet presented a detailed program design. This should include restoration of ecological heterogeneity and use of an appropriate groundcover species.
   1. Mitigation and management strategies should follow those recommended by White et al. (2014), including efforts to reproduce in-stream channel and riparian conditions similar to those of the pre-diversion, restore natural patterns of vertical and lateral hydrological connectivity (e.g. hyporheic exchange, floodplain renewal flows) and re-establish riparian vegetation as rapidly as possible.
   2. The revegetation strategy should specify the expected trajectory of vegetation response and monitoring of this response (White et al. 2014). Further guidance on diversion design and monitoring is provided in White et al. (2014). Revegetation should be based on use of local seedstock rather than exotic species such as Buffle grass.
   3. If the diversion is to proceed, it is important that it is designed to restore and maintain the ecological functions and heterogeneity provided by the current channel, including provision of habitat heterogeneity.
3. Aquatic and riparian habitat will be removed from at least three sections of the Isaac River (45 m wide for the conveyor and haul road, 40 m wide for the Olive Downs South domain access road, 60 m wide for the Olive Downs South domain haul road, App. C, p. 154). The IESC acknowledges the proponent’s efforts to restrict the riparian clearing as much as possible. Nonetheless, the longitudinal connectivity of the Isaac River and its riparian vegetation will be disrupted, adversely affecting the movements of the State and Commonwealth-listed Greater Glider and other biota that use the riparian corridor in this highly fragmented landscape. There are limited mitigation options apart from those suggested by the proponent (e.g. speed limits to reduce incidence of vehicle strike).
4. Given uncertainty remains about which areas are GDEs (see discussion in response to Questions 1 and 2), it is unclear whether the predicted drawdown will result in an impact to a GDE, and if so, to what extent. As discussed in response to Question 2, further work is required in the GDE assessment to confirm where GDEs occur and to understand if and how groundwater drawdown will impact GDEs. An ecological baseline assessment should be undertaken using mapping tools recommended in Richardson et al. (2011). Specific guidance on remote-sensing approaches is available in Emelyanova et al. (2017). Once this information is obtained, appropriate monitoring strategies can be devised to detect alterations to groundwater regime and water quality that would initiate suitable mitigation and management. This is especially relevant for groundwater-dependent riparian vegetation and large areas of remnant native vegetation that include EPBC Act-listed species and/or provide valuable habitat and other resources.
5. The proponent predicts up to 2 m of groundwater drawdown along two stretches of the Isaac River (approximately 4 km at the northern end of the project area and approximately 2.5 km adjacent to the Willunga Domain) and up to 5 m of drawdown in the downstream reaches of Ripstone Creek. Groundwater-dependent vegetation is likely to be stressed by groundwater drawdown, which will reduce ecological resilience. This effect will be most severe if project-induced drawdown coincides with other stressors, such as a prolonged dry period. There may be demographic changes to the ecosystem, with established trees less able to adapt to a changed water table. Seedling establishment and plant recruitment are likely to be impaired. A less resilient ecosystem may be more vulnerable to weed invasion.
   1. To accelerate recovery of lost or depleted riparian vegetation, local-provenance seed-stock should be used for direct seeding and to generate tubestock for planting. Such revegetation should seek to re-establish floral assemblages and habitat structure that resemble pre-mining vegetation communities.
   2. The proponent should use appropriate weed management to partially mitigate impacts weeds that are direct competitors for remnant and replanted native trees.
   3. Currently, the proponent has only considered clearing impacts in their provision for ecological offsets (EIS, App. H of App. A). While the IESC notes that it may not be possible to fully mitigate impacts from groundwater drawdown, the effects of this predicted drawdown should also be considered in planning offsets for wetlands.
6. In the groundwater assessment (EIS, App. D), it is stated that shallow groundwater is present as perched aquifers. As discussed above under the Groundwater section and in response to Question 2, there is evidence in some areas that there is connection between shallow and deeper groundwater. It should therefore not be assumed that shallow aquifers on which vegetation is dependent will not be affected by groundwater drawdown.
7. The proponent suggests that wetlands in the project area are unlikely to be groundwater dependent, but few data are presented to support this claim (EIS, App. D, p. 75). If these wetlands are partially dependent on groundwater, then groundwater drawdown will reduce water levels and/or permanence of water. These alterations of water regime are likely to adversely affect water quality (e.g. dissolved oxygen, salinity), alter rates of ecological processes such as organic matter breakdown and limit habitat availability for aquatic biota. There may also be loss of fringing vegetation. The uncertainties about the source of water in wetlands are described under the Groundwater section in response to Question 2.

#### Final Landform and Voids

1. The proposed mine plan will result in two final voids in the ODS domain and one in the Willunga domain. The two ODS voids would be located within the existing floodplain of the Isaac River.. This proposed landform has a number of risks, summarised below.
   1. Although the proponent’s modelling shows that water levels in the voids will equilibrate well below the overflow levels, this modelling does not examine the effects of extreme events. The proponent should examine the effects of successive high-rainfall years on void levels to ensure that climatic variation will not result in overtopping.
   2. The final voids will ultimately contain hypersaline water which will continue to increase in salinity until saturation is reached and salts precipitate. These voids will be a permanent legacy of mining on the environment.
      1. Consideration should also be given to how this higher density water will affect groundwater flow i.e. the void may no longer become a groundwater sink due to this density contrast and how this may impact on groundwater in the alluvium and baseflow in the Isaac River.
   3. The waste rock emplacements will reduce the extent of the floodplain. This will increase flow velocities in the river channel and permanently reduce potential floodplain habitat.
   4. The waste rock emplacements will alter the surface hydrology, which is likely to adversely impact remnant floodplain vegetation, particularly the establishment and growth of seedlings.
   5. There is a risk that surface water could seep through the waste rock emplacement into the final void. Waste will have different hydraulic properties compared to undisturbed rock, meaning that there may be higher or lower fluxes of groundwater, with implications for surface water and baseflow.
2. These risks would be most effectively mitigated by avoiding mining or placement of waste rock on the floodplain. The potential risk of overtopping and hypersaline water leakage would be reduced by partial backfilling to above the water table or to an elevation above any aquifers that are a major source of salts.
3. If mining does proceed as proposed, consideration should be given to capping of the section of the emplacement that will be exposed to flood flow (e.g. with non-cracking clay) to minimise unwanted infiltration. The proponent should also monitor conditions in the Isaac River channel after flood events to determine whether the additional flow velocities result in substantial scour. If they do, appropriate remediation, such as armouring, should be undertaken.
4. The proponent notes in their soils assessment (EIS, App. M) that subsoils across much of the project area are dispersive. This presents a risk to downstream water quality if not appropriately managed. The proponent identifies handling measures for different soil types (EIS, Section 5; EIS, App. M) to help reduce erosion risk. The IESC notes that a recent ACARP report (Dale et al. 2018) provides valuable guidance on successful mine rehabilitation in areas with dispersive soils, based in part on experience of other mines in the Bowen Basin. This guidance would be valuable in further refinement of the rehabilitation strategy and in designing suitable monitoring to confirm that rehabilitation is functioning as designed. Vegetation rehabilitation monitoring will be essential to ensure long-term viability and facilitate adaptive management (for example, alternative plant species) where needed. Monitoring sites should be established in rehabilitated areas. Their floral assemblages and vegetation structure should be compared with those in appropriate references sites monitored at the same time. Photographic transects and annual surveys of species composition and condition are recommended.
5. The proponent’s geochemical assessment of spoil and coal rejects (EIS App. I) does not provide physico-chemical characteristics of the water used as leach solution. An acidic leach solution would potentially have leached higher metal concentrations. Without this information (particularly on pH), it is difficult to assess whether the test results adequately replicate expected conditions to provide a valid assessment of risk. It is important that geochemical assessments are conducted under conditions indicative of those expected in the field (e.g. aerial exudation and leaching processes).

Question 5: Advice is sought on whether the draft EIS gives an adequate consideration to the project's contribution to cumulative impacts associated with other mining activities and coal seam gas production in the area?

1. The proponent has provided an appropriate assessment of potential cumulative groundwater impacts for the project, through incorporation of information from neighbouring mines and the proposed coal seam gas project into the numerical model. The provision of multiple modelling scenarios – with no mining, approved and foreseeable mining, and approved and foreseeable mining plus the proposed project – would allow clear identification of cumulative and project-specific impacts.
2. While the proponent gives some contextual information in their assessment of impacts to surface water and ecology, they have not provided robust cumulative assessments. Such an assessment is important, given the high level of recent and planned development in the Bowen Basin. Riparian vegetation is of particular importance, as it provides valuable habitats and movement corridors, including for State and Commonwealth-listed biota, in this extensively fragmented landscape.
3. When the proponent prepares the REMP, consideration should be given to the way in which pre-mining data are treated. The existing monitoring point ISDS, installed to collect baseline data (downstream of the project area), is downstream of the confluence with Stephens Creek. Norwich Park Mine has four discharge locations on tributaries of Stephens Creek. In addition, the Peak Downs, Saraji and Lake Vermont coal mines all have approval to discharge into Boomerang Creek or Phillips Creek (or their tributaries) which flow into the Isaac River upstream of the ISDS monitoring point but downstream of the Deverill monitoring point. It is therefore likely that a monitoring and gauging location upstream of the confluence of Boomerang Creek will also be needed to determine the proportion of water quality and flow changes caused by discharges from the proposed project, noting that the majority of discharges are proposed to come from the Olive Downs South mining area.
4. The project will result in a decrease in catchment area to the Isaac River of approximately 1 percent. Although this is small, it is cumulative with other catchment reductions in the region from coal mining. There will also be disruptions of the riparian vegetation corridor of both the Isaac River and Ripstone Creek (Paragraphs 37–38) as well as loss or modification of seven wetlands of High Ecological Significance. These disruptions and losses are highly likely to compound current losses of ecological connectivity at the regional scale, including of EPBC Act-listed species and communities.
5. To enable a robust assessment of cumulative impacts to surface water resources and to EPBC Act-listed species and communities, the proponent should provide:
   1. information on the recent regional impacts to EPBC Act-listed species and communities and to wetlands. This information may be available from remote sensing data and from proponents’ environmental assessments and subsequent monitoring data;
   2. an assessment of the potential cumulative impacts to the Isaac River from mining activities. This should include an assessment of the current volumes and quality of mine-affected water, and associated contaminant loads, currently discharged to the catchment, an estimation of the total area of disturbed catchment, and contextual information on diversions within the catchment. This information should be presented in a way that shows the resulting cumulative impacts on flow regimes in the Isaac River. The impacts on flows in Isaac River would be best communicated by showing seasonal flow regimes:
      1. without mining impacts;
      2. with current mining impacts;
      3. with current mining impacts plus the proposed project;
      4. during wet and dry climactic conditions.

This approach would be consistent with the way that cumulative impacts have been presented in the groundwater assessment in the EIS; and

* 1. an assessment of the potential cumulative impacts (both quantity and quality) of mining activities on the water resources downstream. Loss and modification of wetlands in the project area will ultimately, as part of the ongoing loss of wetlands in the Bowen Basin, contribute to poor water quality downstream in the Fitzroy River, the Fitzroy estuary and the nearshore marine environment.

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| Date of advice | 9 October 2018 |
| Source documentation available to the IESC in the formulation of this advice | Draft Environmental Impact Statement for the Olive Downs project, prepared on behalf of Pembroke Resources 2018 (cited as EIS):  Section 1-lntroduction  Section 2-Project Description  Section 3-Assessment of Matters of National Environmental Significance  Section 4-Assessment of Project Specific Matters  Section 5-Rehabilitation Strategy  Section 6-Environmental Protection Commitments and Model Conditions  Section 7-References  Appendix A-Terrestrial Flora Assessment  Appendix B-Terrestrial Fauna Assessment  Appendix C-Aquatic Ecology Assessment  Appendix D-Groundwater Assessment  Appendix E-Surface Water Assessment  Appendix F-Flood Assessment  Appendix L-Geochemistry Assessment  Appendix M-Soil and Land Suitability Assessment  Appendix 0-Preliminary Risk Assessment  Attachment 4-Peer Review Letters |
| References cited within the IESC’s advice | Aquatic Ecosystems Task Group 2012. Aquatic Ecosystems Toolkit. *Module 2. Interim Australian National Aquatic Ecosystem Classification Framework.* Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available [online]: <http://environment.gov.au/resource/aquatic-ecosystems-toolkit-module-2-interim-australian-national-aquatic-ecosystem-anae>.  Ball J, Babister M, Nathan R, Weeks W, Weinmann PE, Retallick M, Testoni I (editors) 2016. *Australian Rainfall and Runoff: A Guide to Flood Estimation*. Commonwealth of Australia (Geoscience Australia).  Boulton AJ, Brock MA, Robson BJ, Ryder DS, Chambers JM and Davis JA 2014. *Australian Freshwater Ecology: Processes and Management*. 2nd edition, Wiley, Chichester.  Dale G, Thomas E, McCallum L, Raine S, Bennet J and Reardon-Smith K 2018. *Applying risk-based principles of dispersive mine spoil behaviour to facilitate development of cost-effective best management practices*. ACARP Project C24033.  Emelyanova I, Barron O, Vleeshouwer J, Bridgart R 2017. *Application of remote sensing techniques to support delineation and characterisation of groundwater-dependent vegetation: Technical Report.* CSIRO, Australia. Available [online]: <https://publications.csiro.au/rpr/pub?pid=csiro:EP175305>.  IESC, 2018. *Information Guidelines for proponents preparing coal seam gas and large coal mining development proposals* [Online]. Available: <http://www.iesc.environment.gov.au/system/files/resources/012fa918-ee79-4131-9c8d-02c9b2de65cf/files/iesc-information-guidelines-may-2018.pdf>.  Kath J, Reardon-Smith K, Le Brocque AF, Dyer FJ, Dafny E, Fritz L, Batterham M 2014. Groundwater decline and tree change in floodplain landscapes: Identifying non-linear threshold responses in canopy condition. *Global Ecology and Conservation*, 2: 148–60.  Richardson S, Irvine E, Froend R, Boon P, Barber S, Bonneville B, 2011. *Australian groundwater-dependent ecosystems toolbox part 1: assessment framework.* Waterlines report, National Water Commission, Canberra. Available [online]: <http://www.bom.gov.au/water/groundwater/gde/GDEToolbox_PartOne_Assessment-Framework.pdf>.  State of Queensland (Department of Environment and Heritage Protection) 2011. Environmental Protection (Water) Policy 2009. Available: <https://www.ehp.qld.gov.au/water/policy/fitzroy-basin.html>  White K, Moar D, Hardie R, Blackham D and Lucas R 2014. *Criteria for functioning river landscape units in mining and post mining landscapes*. Alluvium. Final report for ACARP Project C20017. |