APPENDIX A – AREA 5 AND AREA 6 SWAMP MONITORING

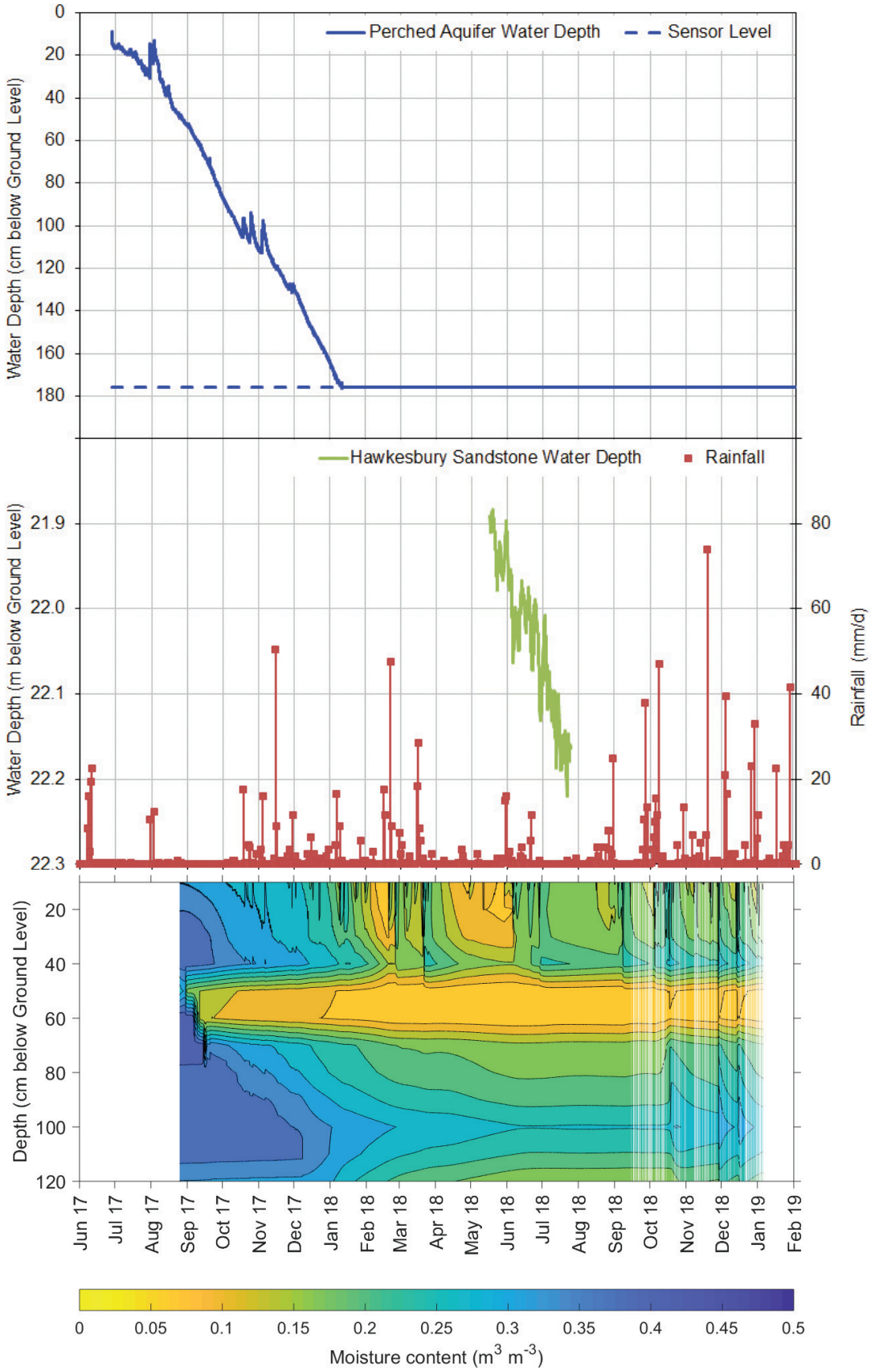
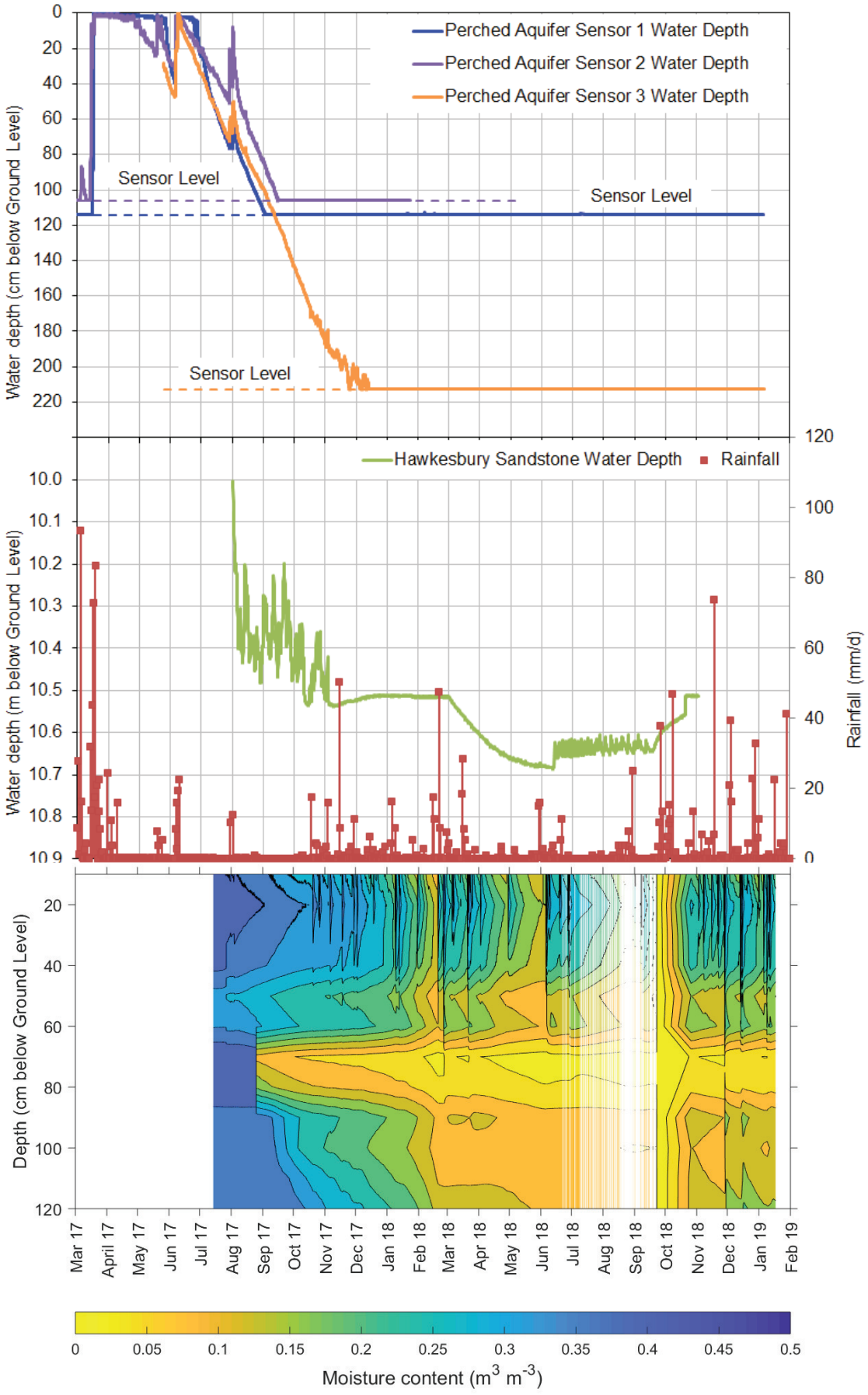


Chart A1 Den 83 - Shallow Groundwater Level and Moisture Content[11]

[11] Blank (white) patches in moisture content plots indicate periods of no data or data errors.



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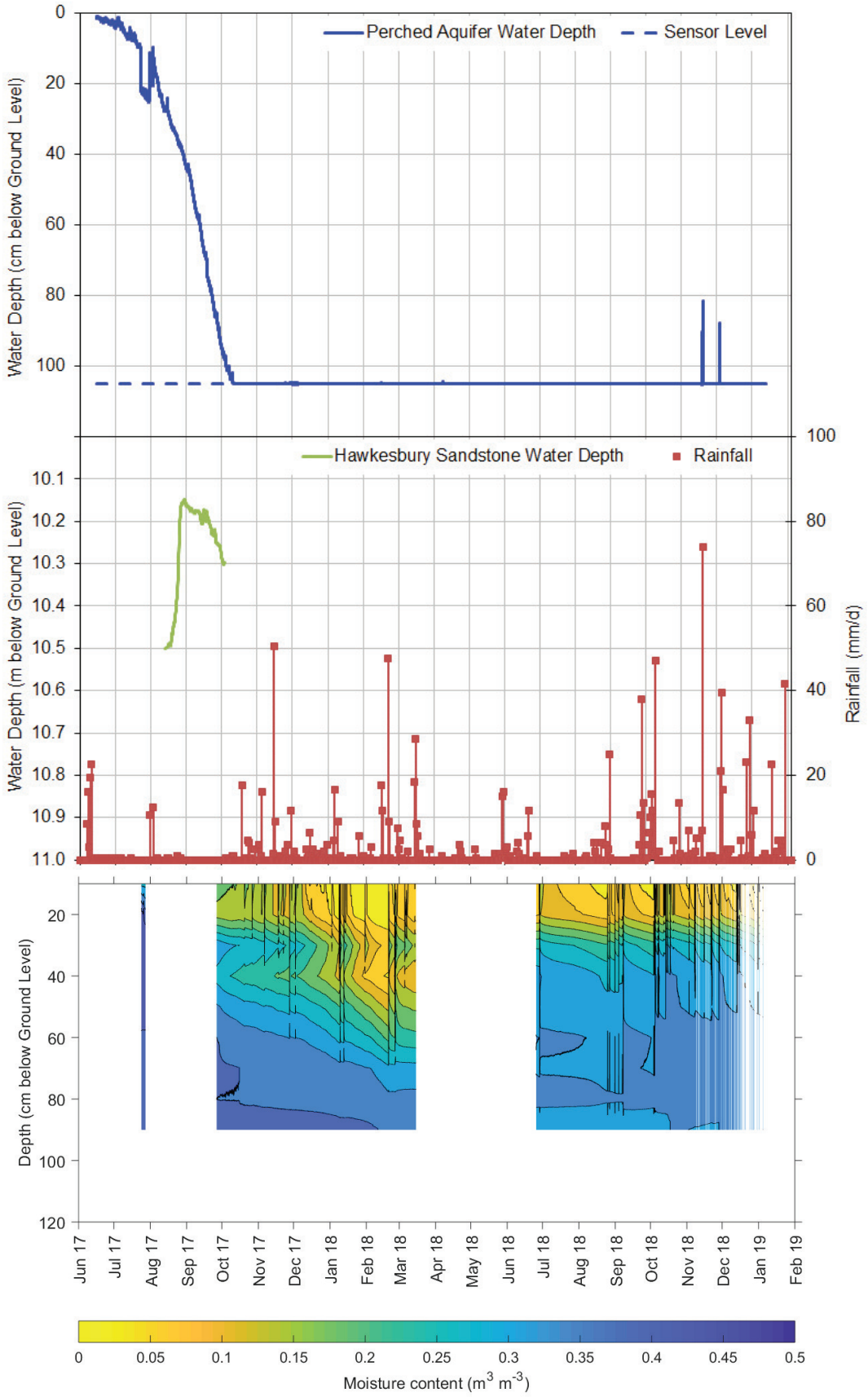

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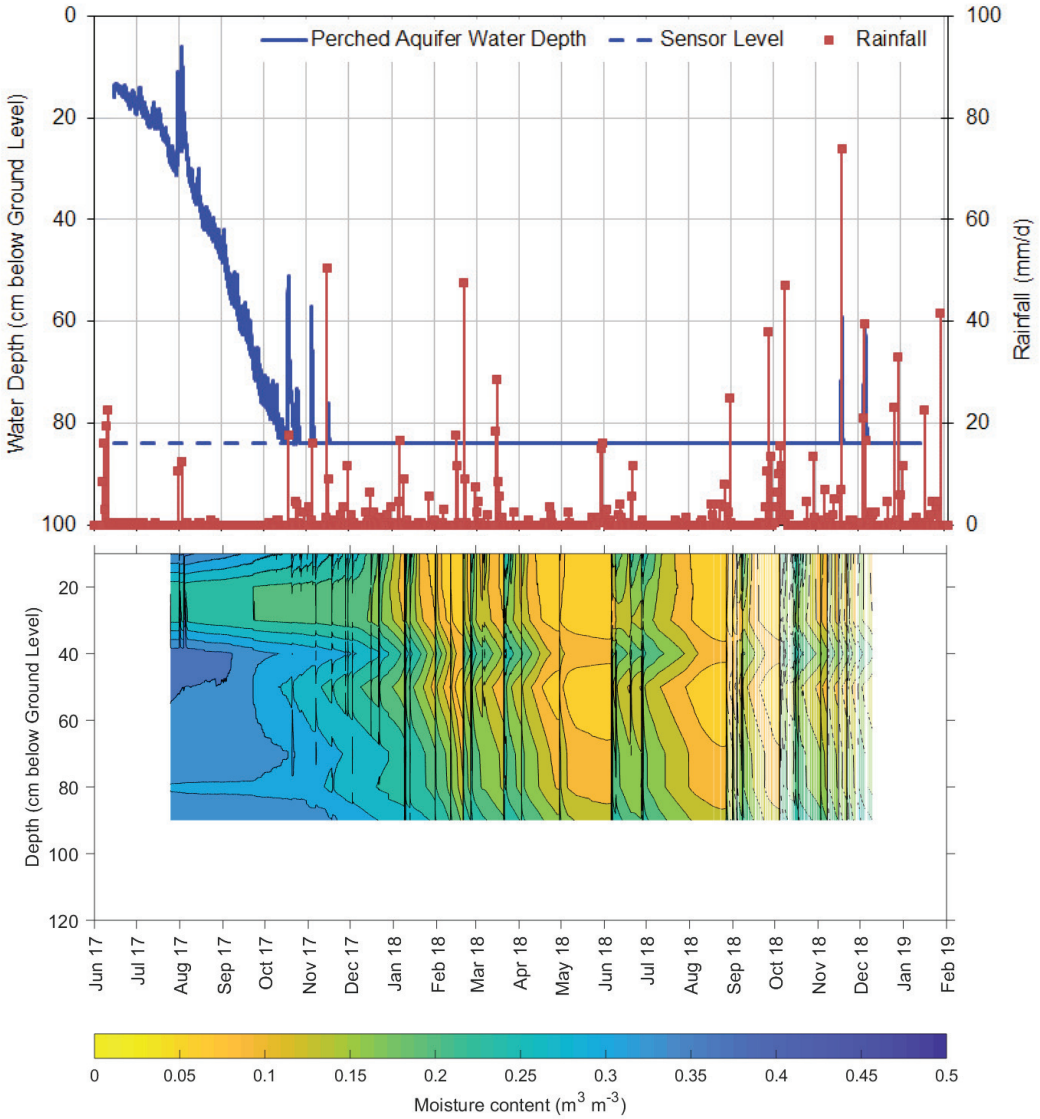


Chart A4 **Den 98 - Shallow Groundwater Level and Moisture Content**

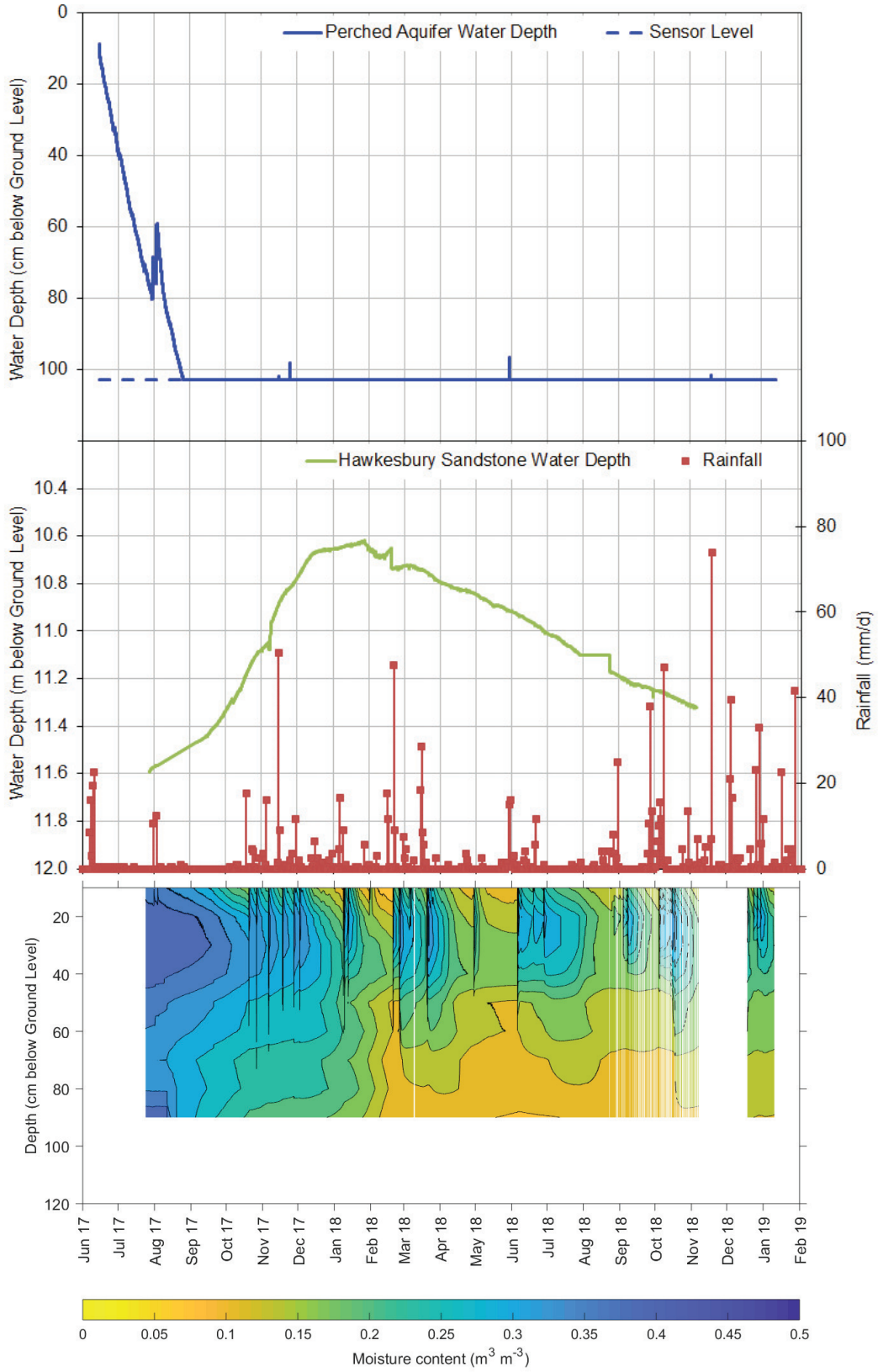


Chart A5 Den 100 - Shallow Groundwater Level and Moisture Content

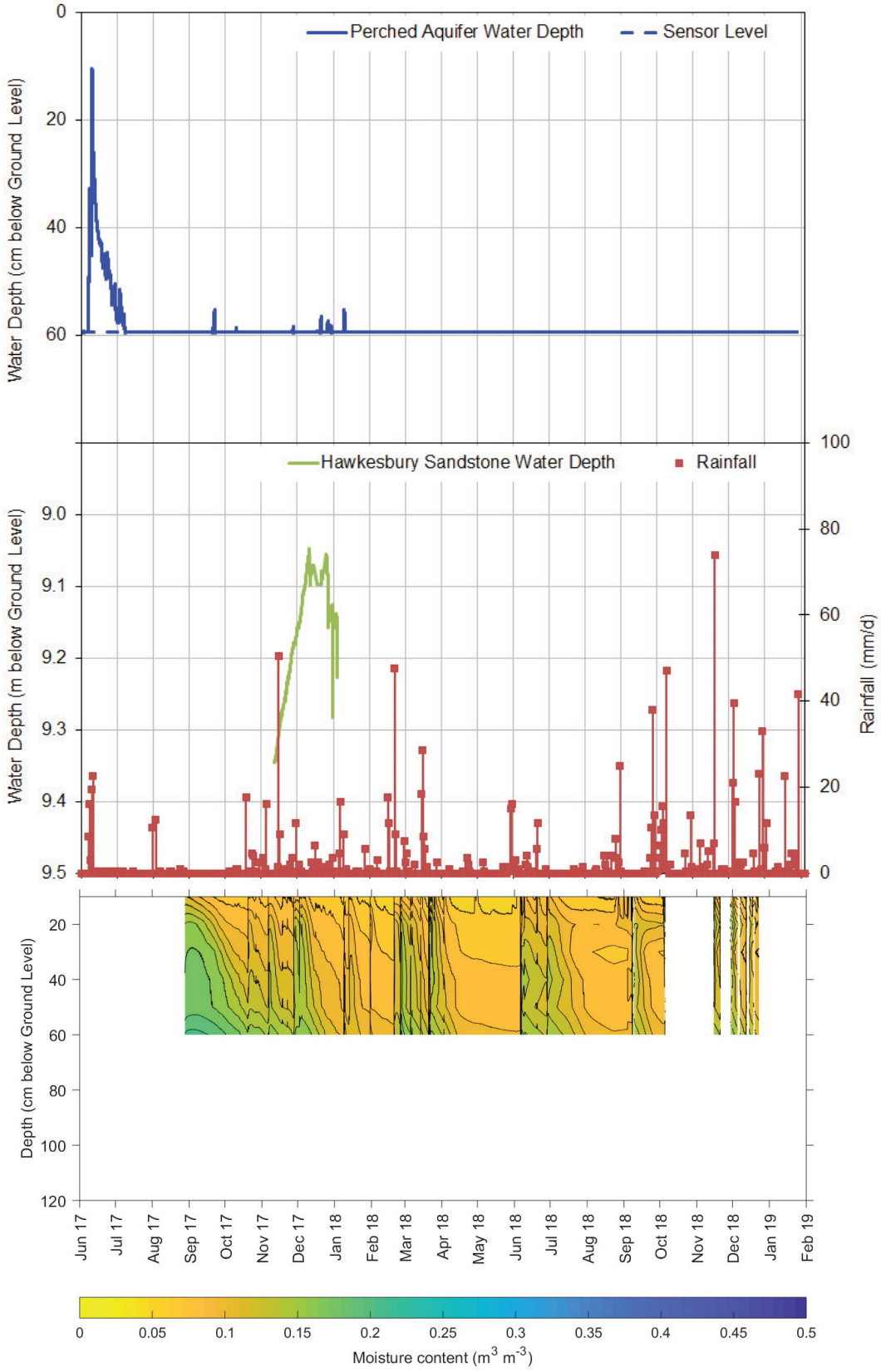


Chart A6 Den 103 - Shallow Groundwater Level and Moisture Content

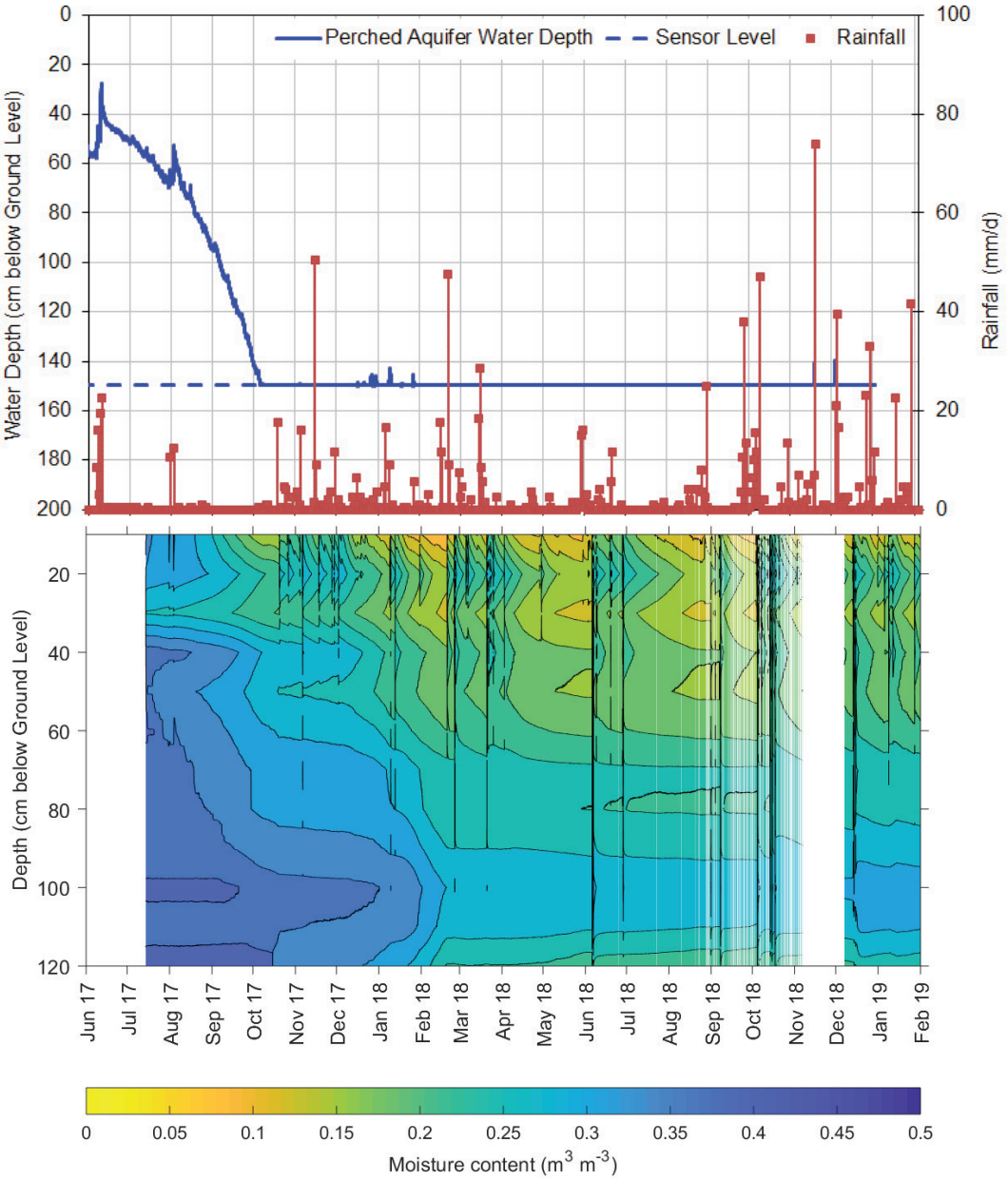


Chart A7 **Den 106 - Shallow Groundwater Level and Moisture Content**

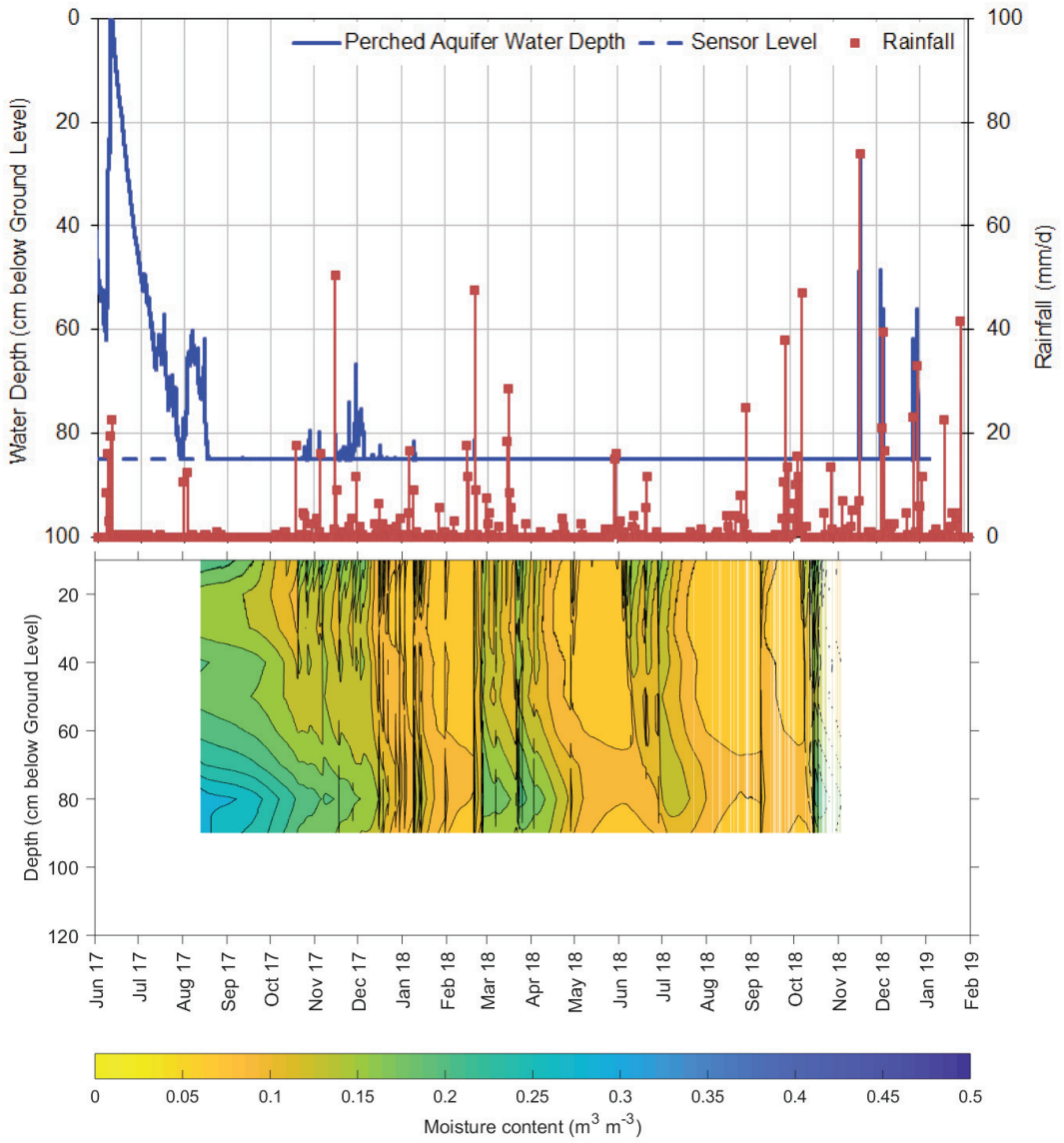


Chart A8 **Den 107 - Shallow Groundwater Level and Moisture Content**

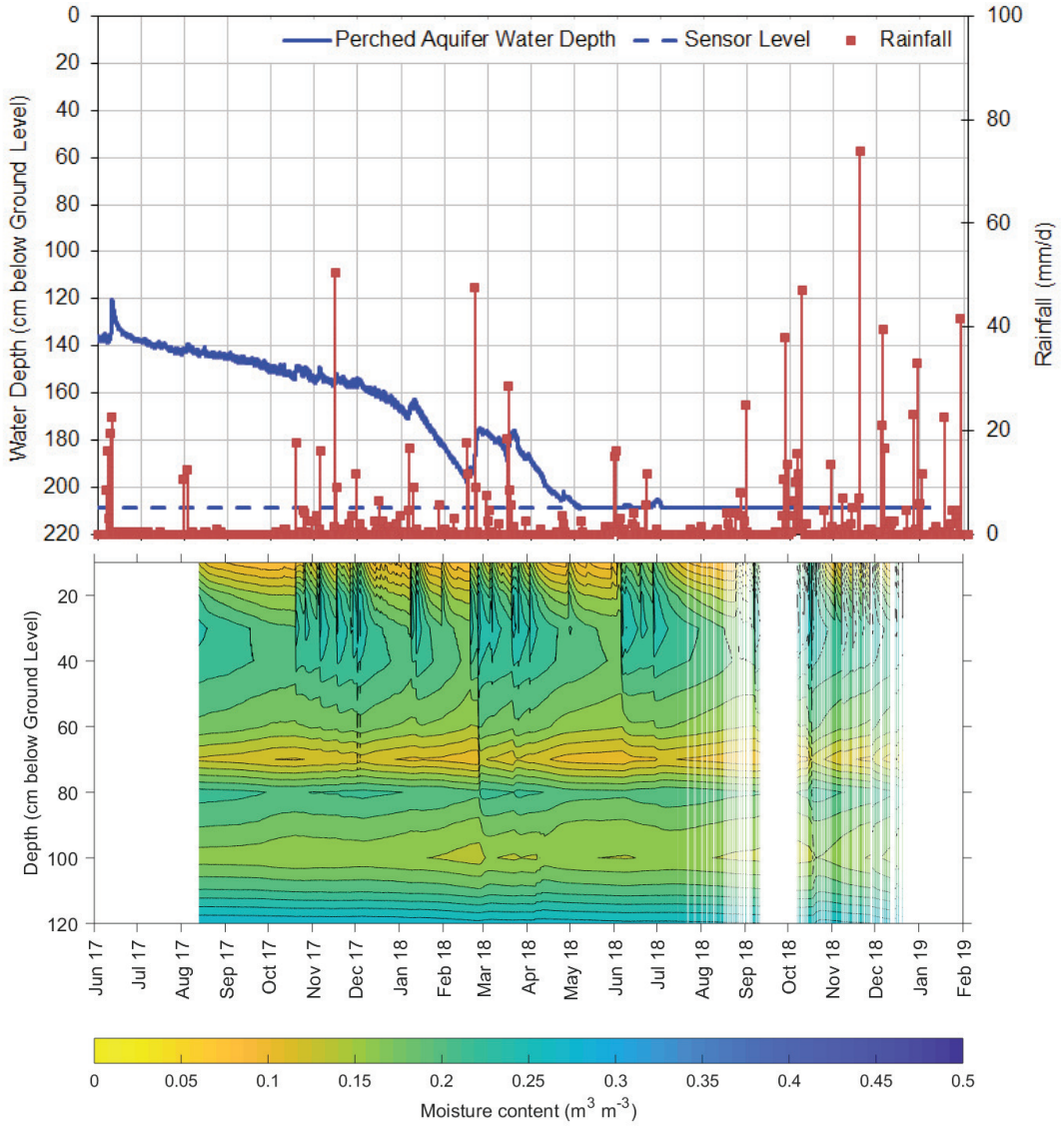
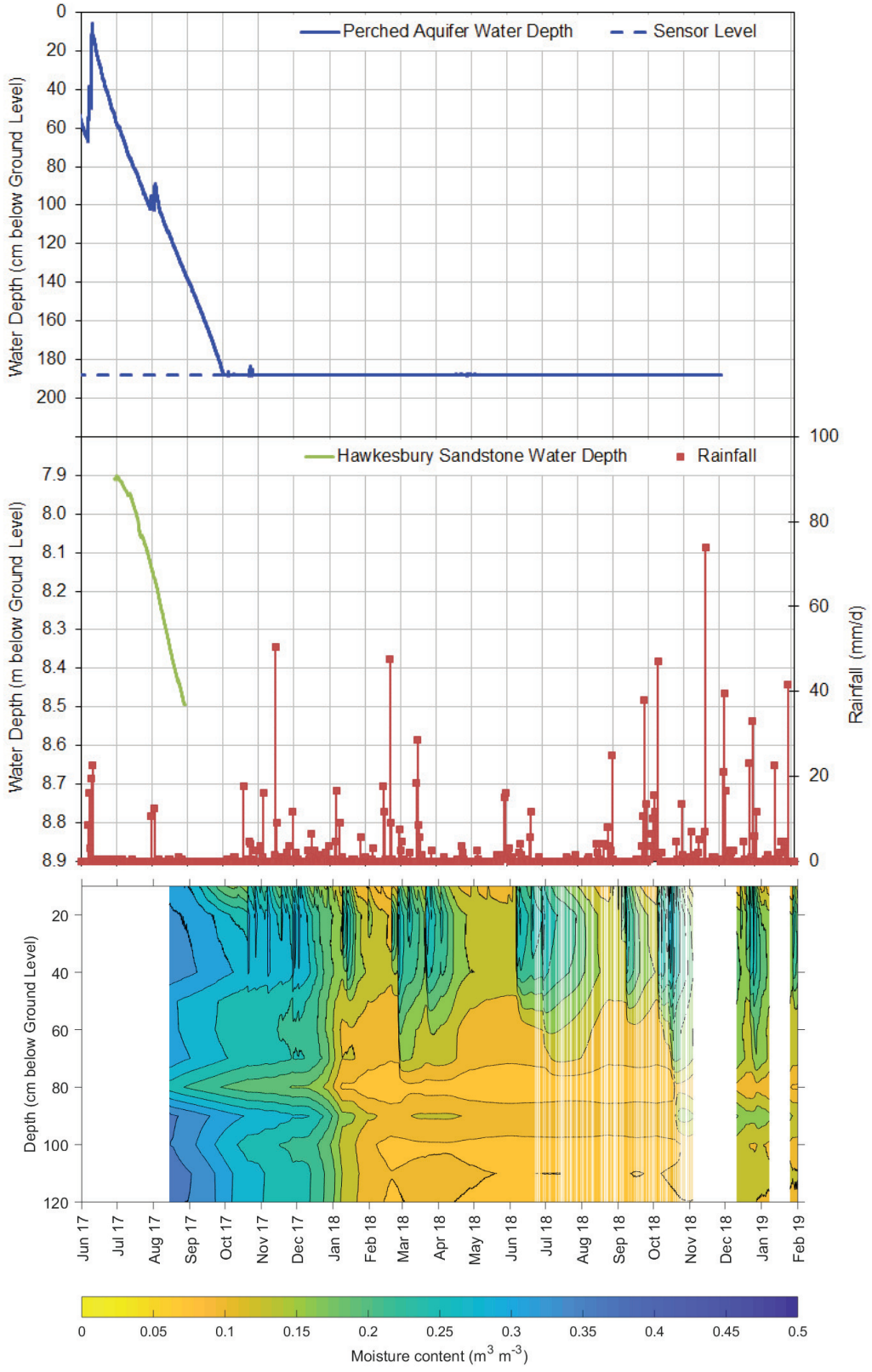


Chart A9 Den 108 - Shallow Groundwater Level and Moisture Content



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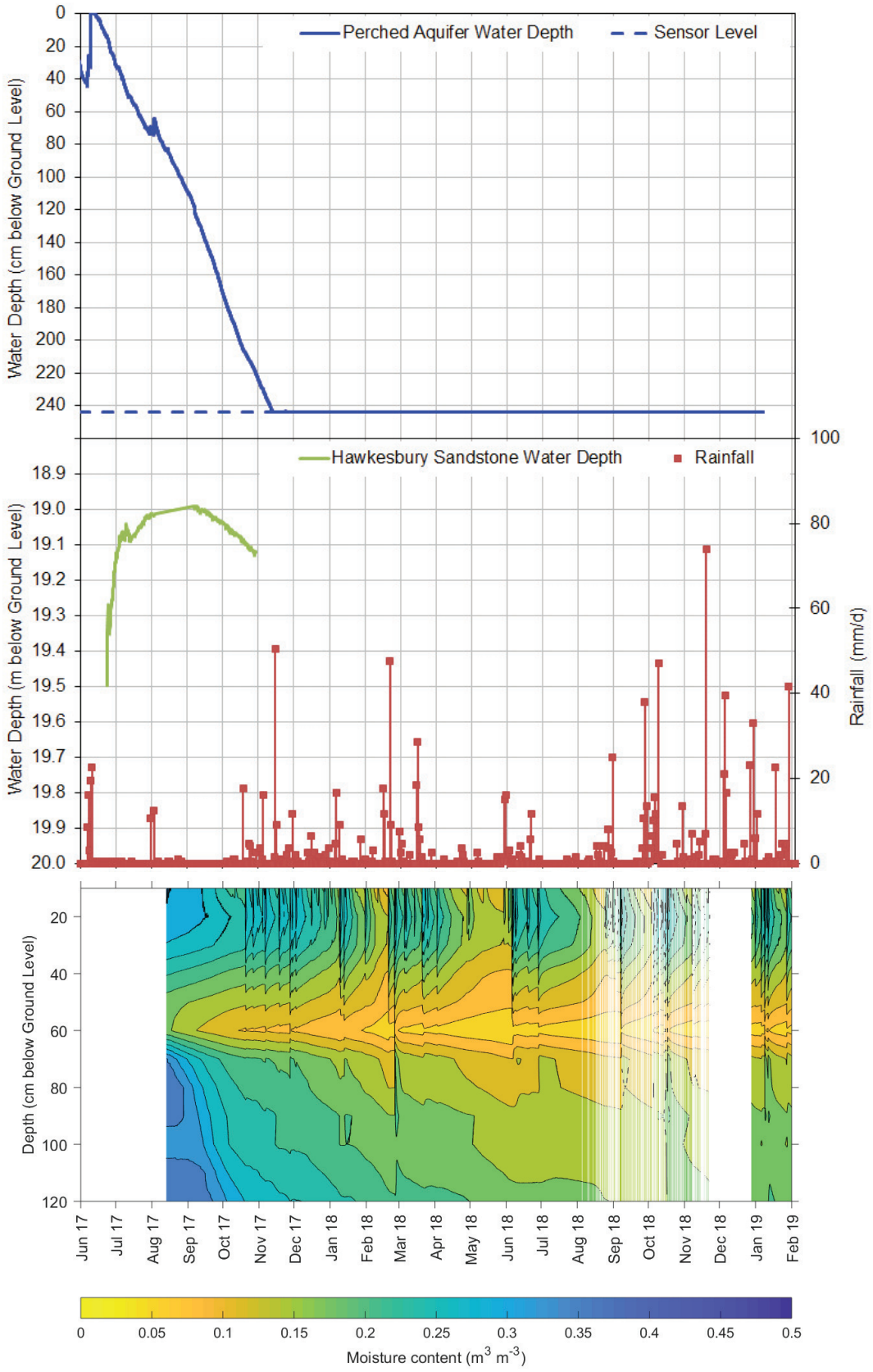

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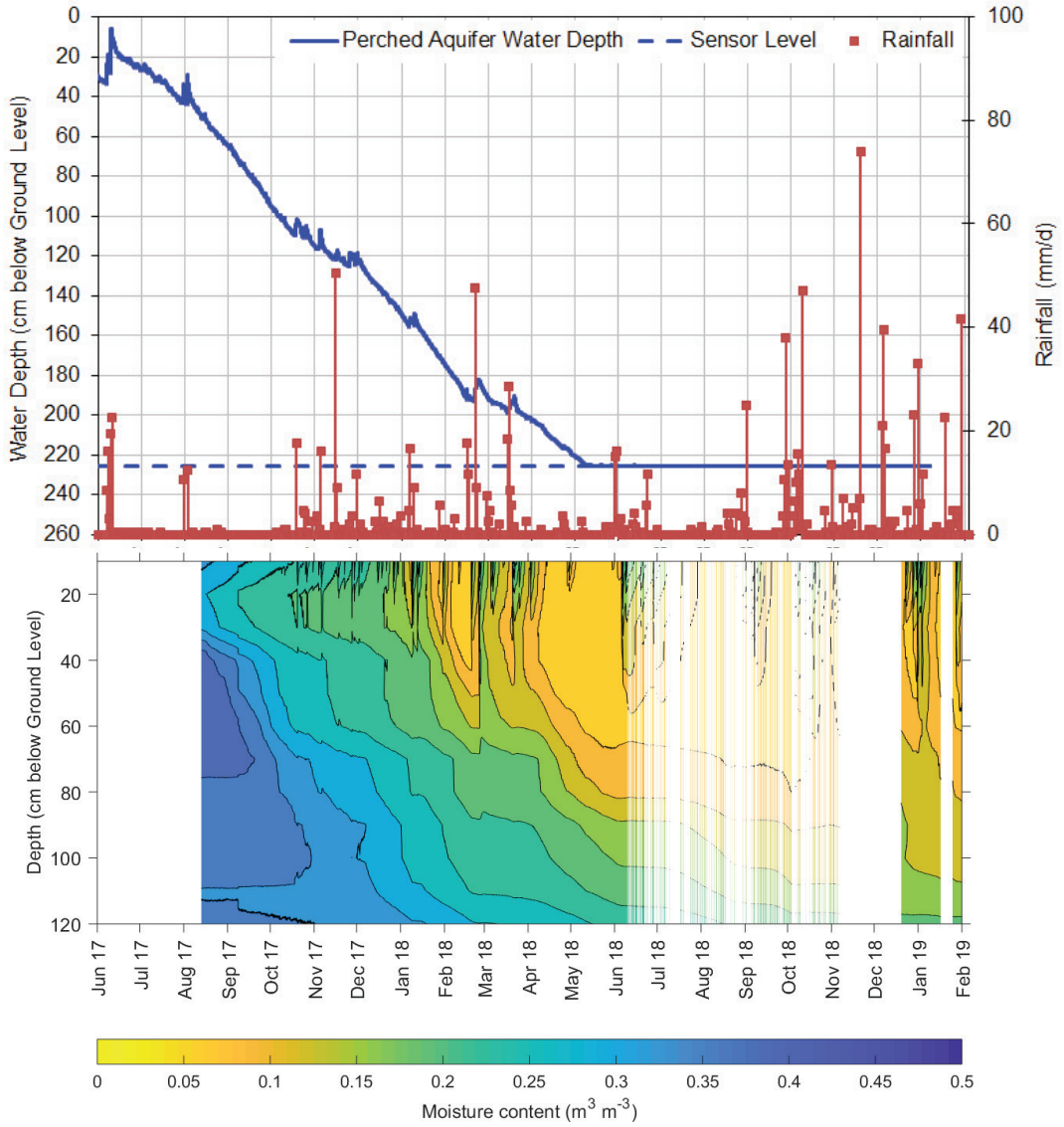

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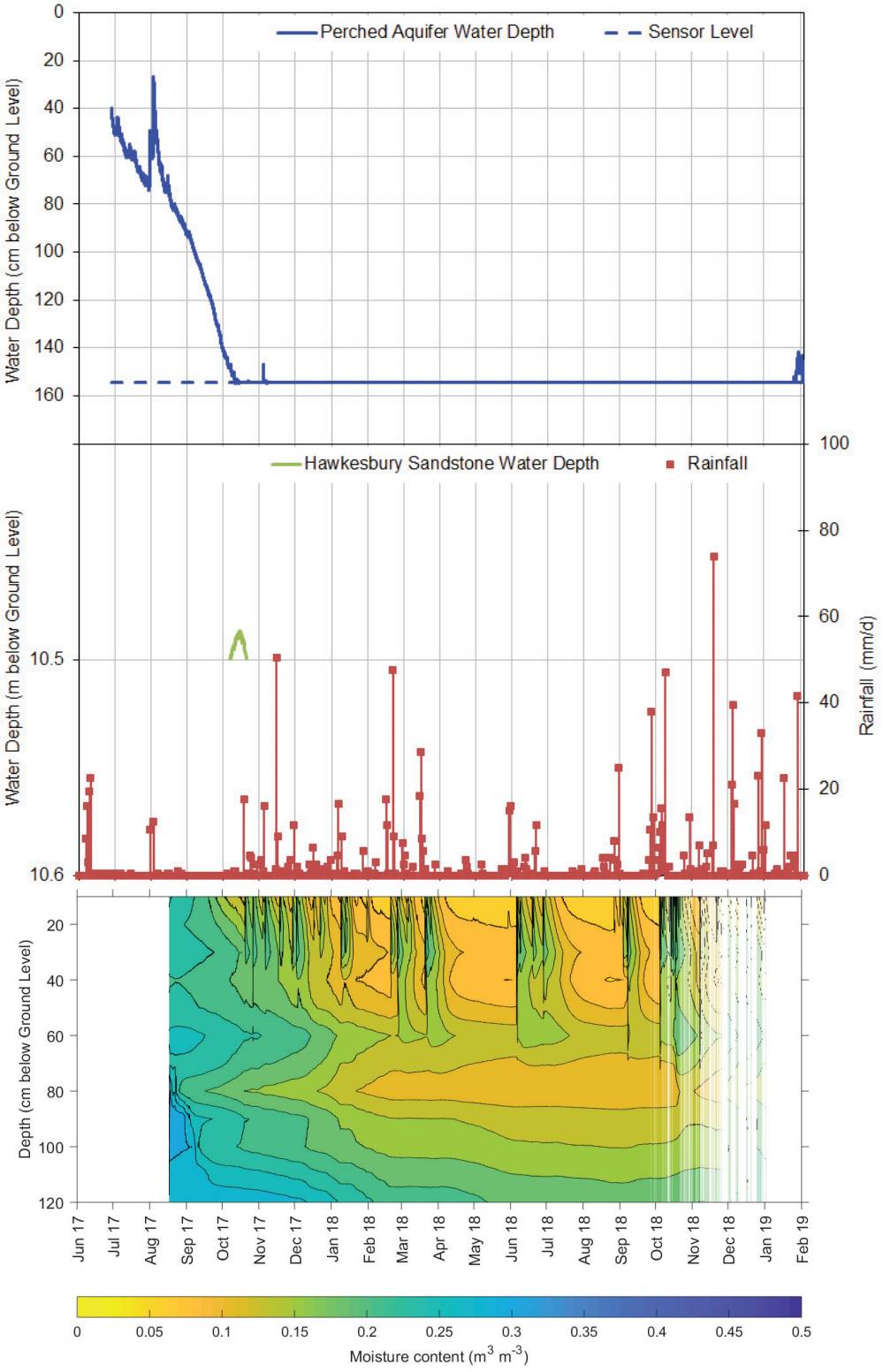

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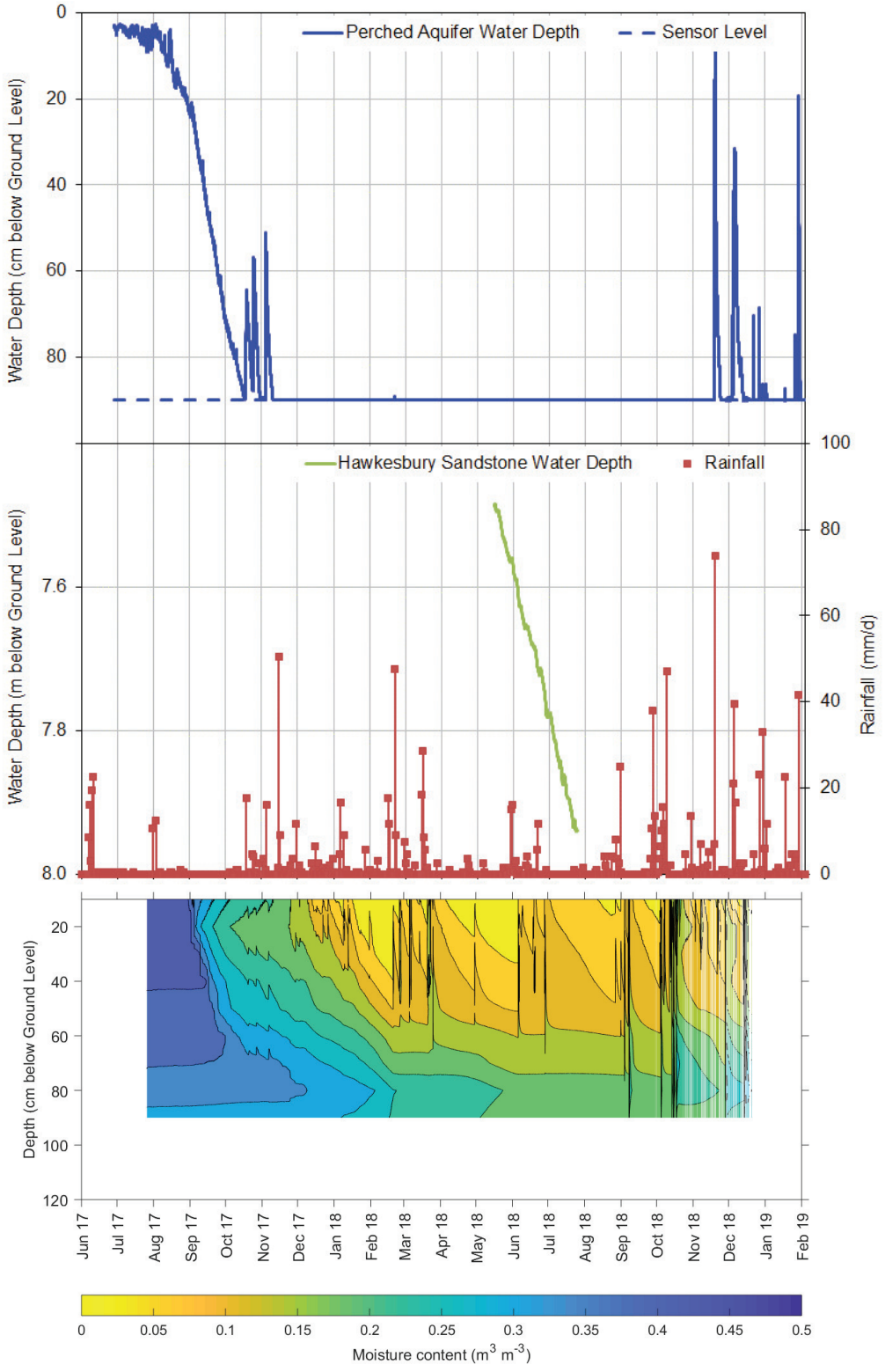

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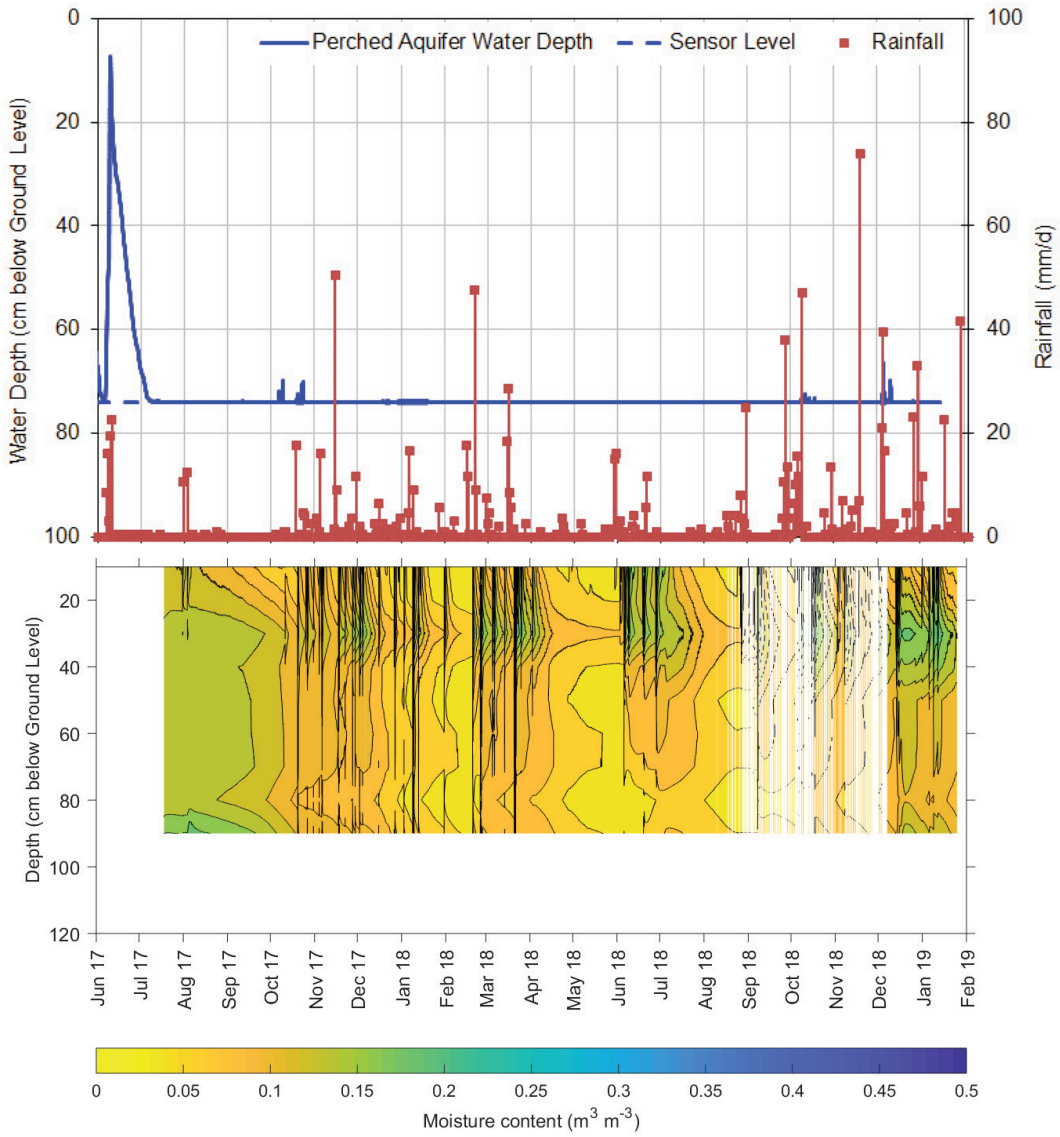

Chart A15 Den 114 - Shallow Groundwater Level and Moisture Content

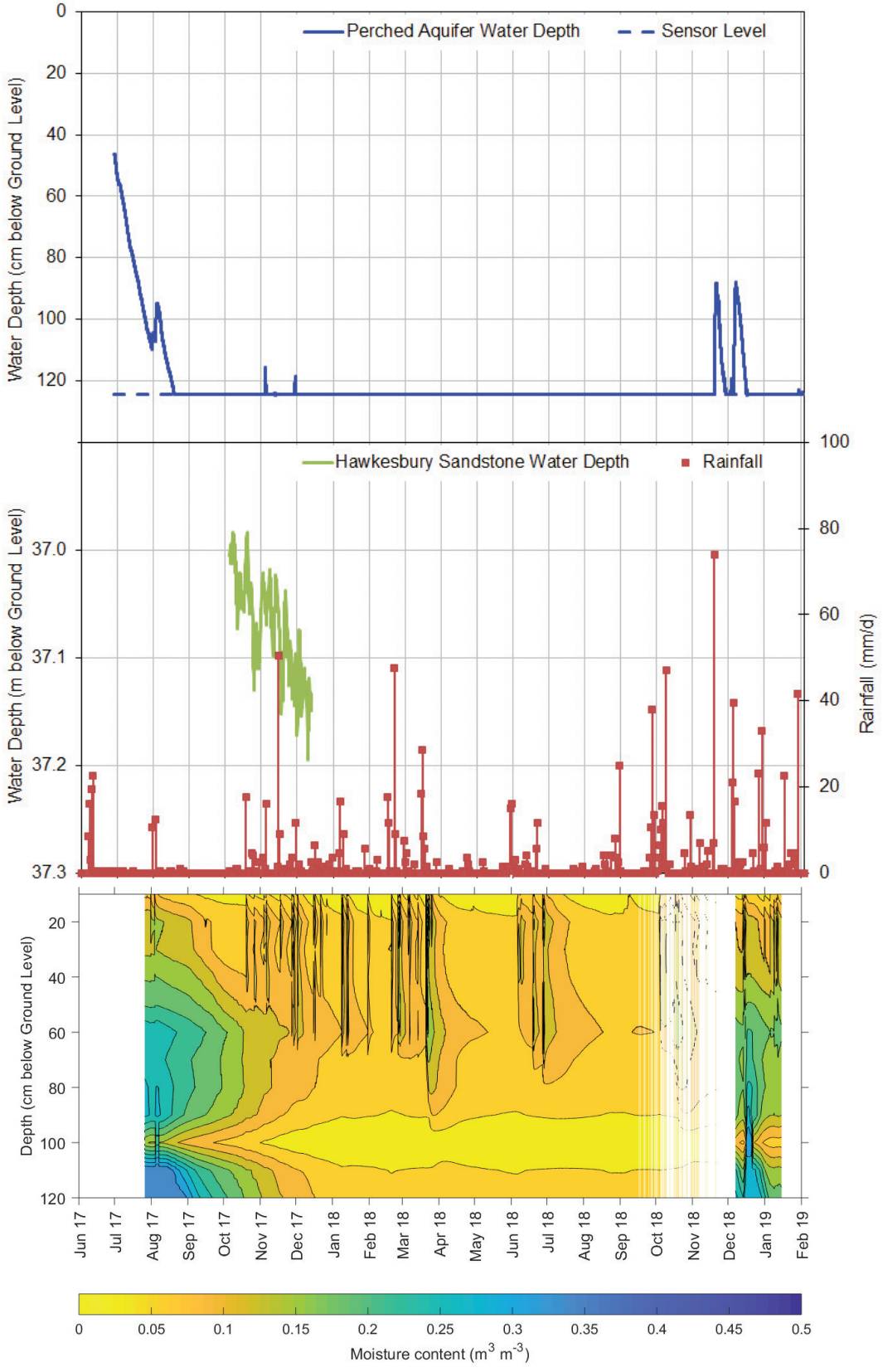

Chart A16 Den 115 - Shallow Groundwater Level and Moisture Content

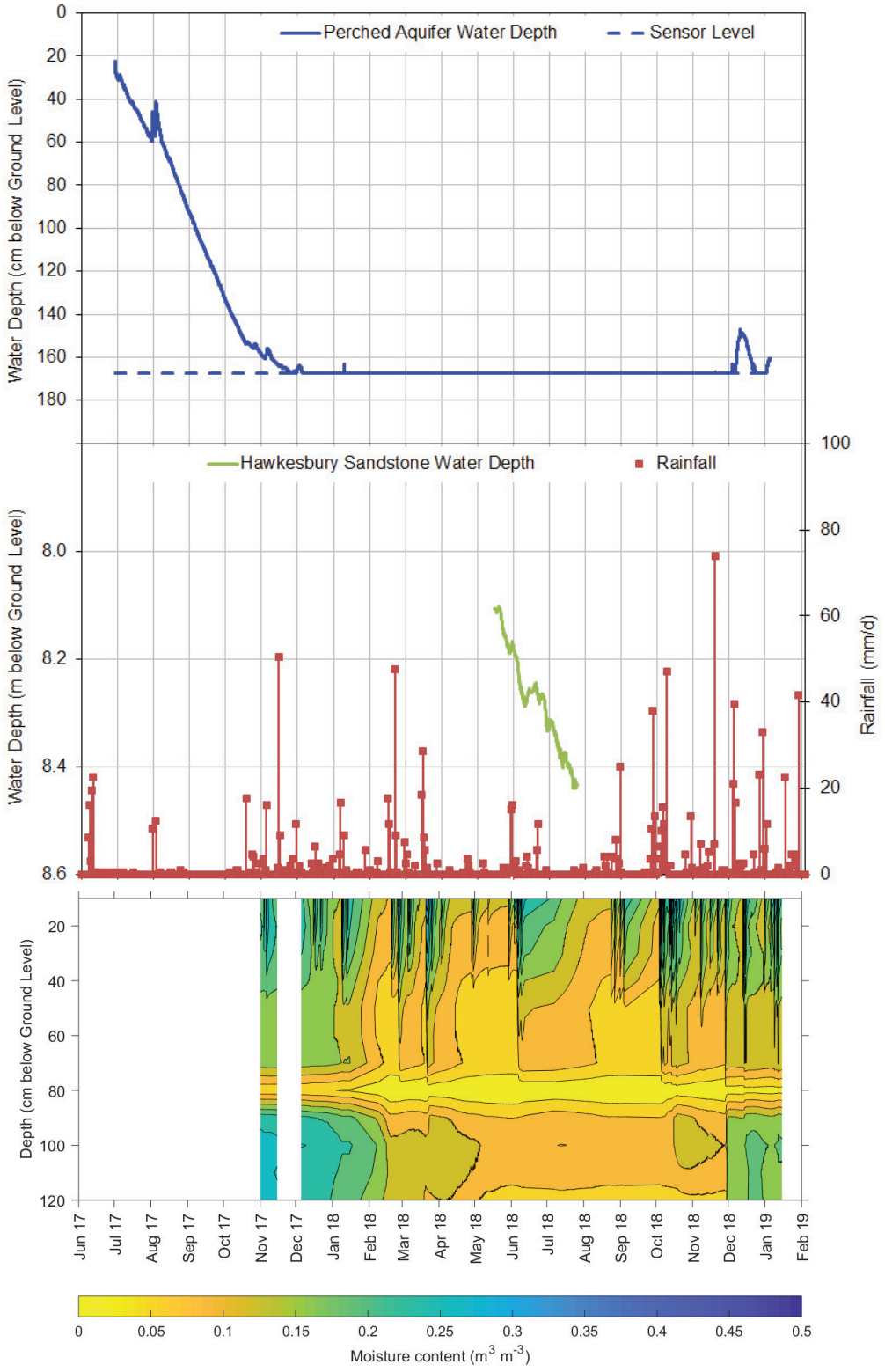

Chart A17 Den 116 - Shallow Groundwater Level and Moisture Content

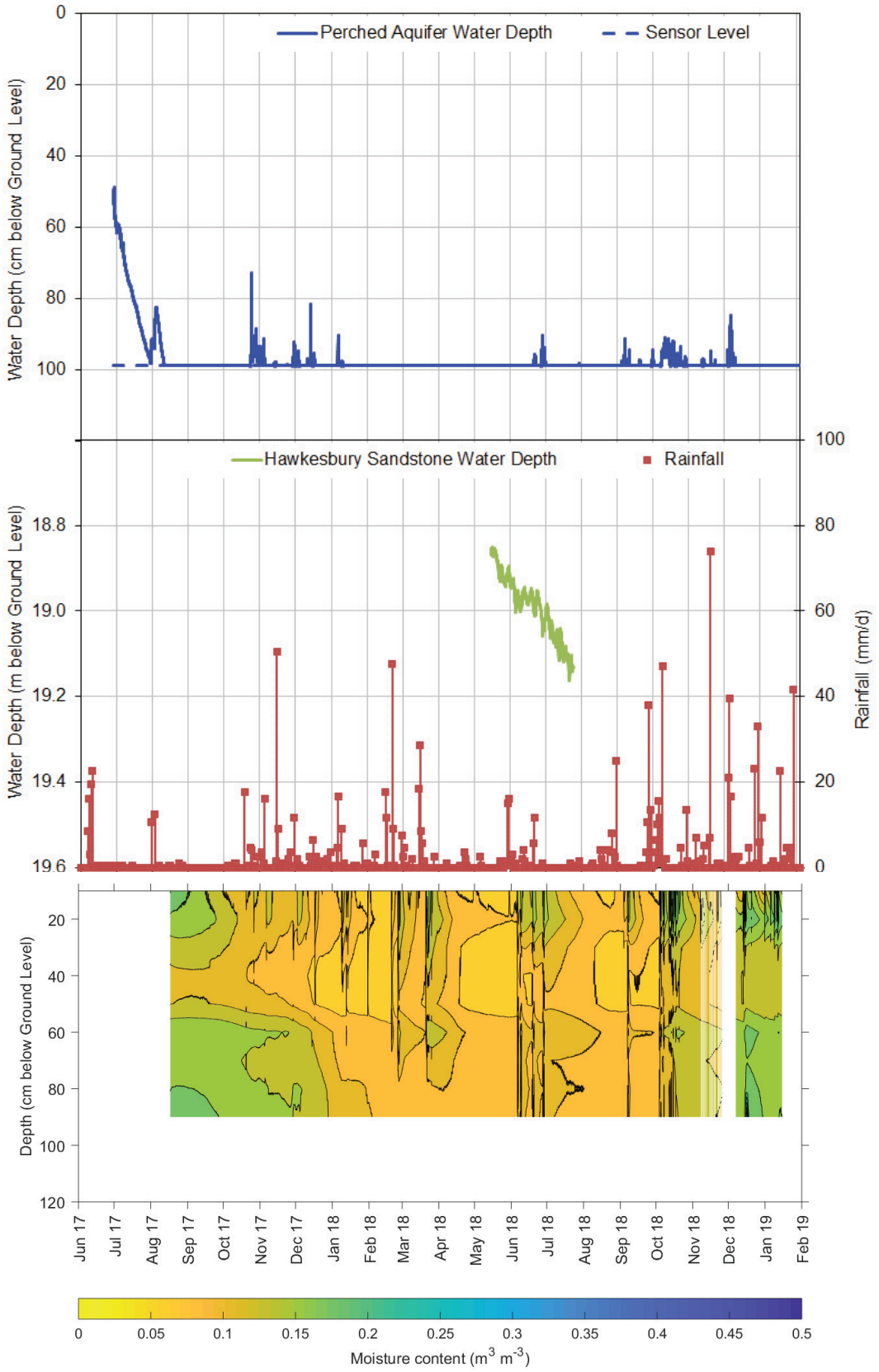

Chart A18 Den 117 - Shallow Groundwater Level and Moisture Content

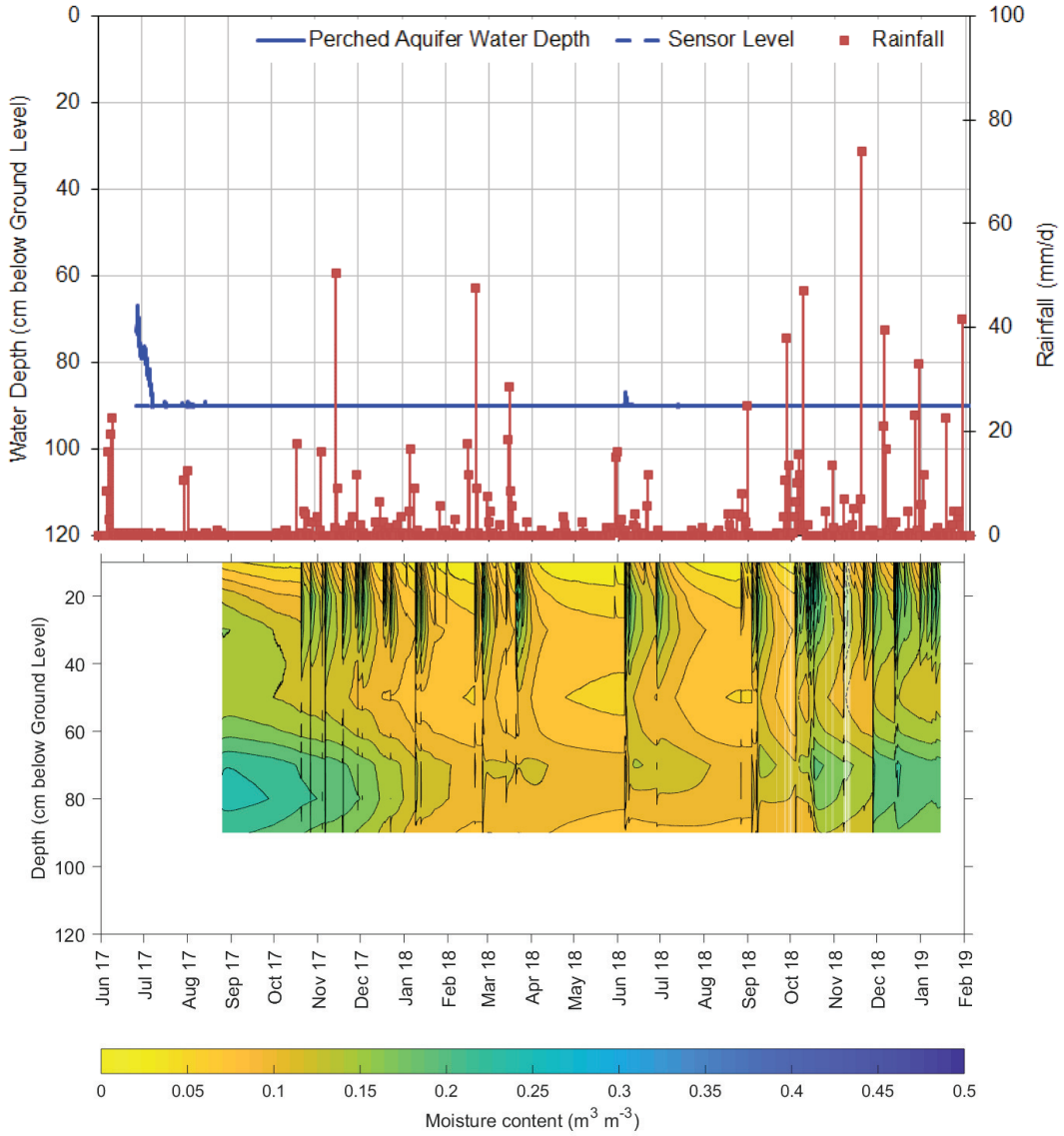

Chart A19 Den 118 - Shallow Groundwater Level and Moisture Content

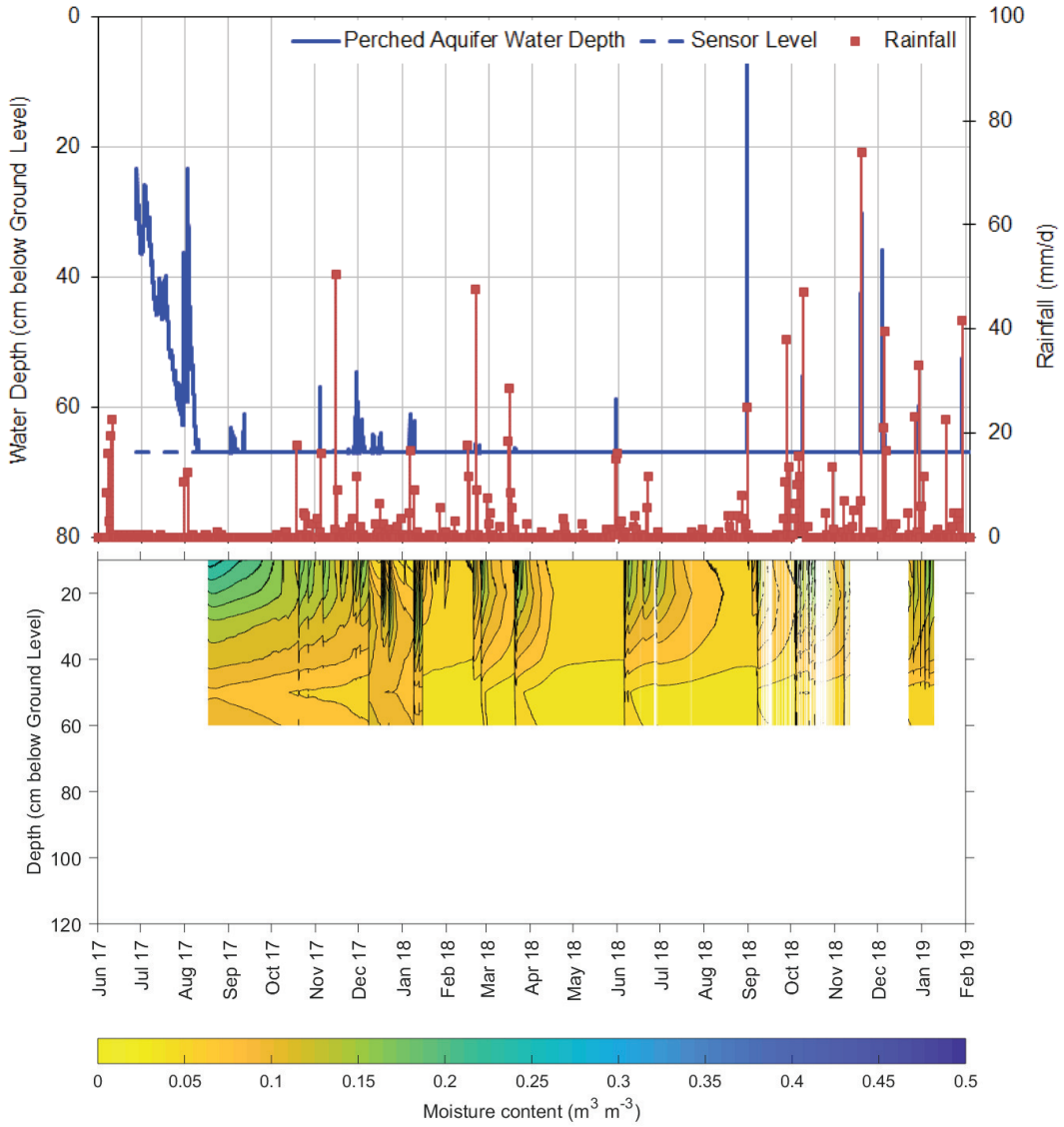

Chart A20 Den 119 - Shallow Groundwater Level and Moisture Content

APPENDIX B – STREAM RISK ASSESSMENT

HYDRO ENGINEERING & CONSULTING PTY LTD

REPORT

Dendrobium Mine
Plan for the Future
Stream Risk Assessment

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c	Final	DNB	Resource Strategies	TSM	30/4/2019
d	Final (with minor changes)	DNB	Resource Strategies	TSM	6/5/2019

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1.0 INTRODUCTION

The Dendrobium Mine (the Mine) is an existing underground coal mine situated in the Southern Coalfield of New South Wales (NSW), with the Dendrobium Pit Top located approximately 8 kilometres (km) west of Wollongong. Illawarra Coal Holdings Pty Ltd (Illawarra Coal), a wholly owned subsidiary of South32 Limited (South32), is the owner and operator of the Mine.

Illawarra Coal is seeking a new Development Consent to gain access to Area 5 and Area 6 within Consolidated Coal Lease (CCL) 768 and for the use of supporting infrastructure, referred to as *Dendrobium Mine – Plan for the Future: Coal for Steelmaking* (hereafter referred to as the Project).

In 2008 the findings of the Southern Coalfield Inquiry (SCI) were documented in the report *Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield - Strategic Review* (herein described as the Southern Coalfield Panel Report [SCPR]) (NSW Department of Planning [DoP], 2008).

In June 2009, the Minister for Planning released the NSW Planning Assessment Commission's (PAC's) Metropolitan Coal Project Review Report (May, 2009) (herein described as the Metropolitan PAC Report). The Metropolitan Coal Project was the first mining proposal in the Southern Coalfield to be assessed under the Environmental Planning and Assessment Act, 1979 (EP&A Act) since the SCPR was published in 2008. Of relevance to this Project, the Metropolitan PAC Report concludes (page 132):

> *The Panel considers that it would be desirable if future proposals for mining in the Southern Coalfield were required to take account of the SCI recommendations as modified by this report in preparing the Project Application and the subsequent EA.*

Specifically, Recommendations 2, 3 and 11 of the Metropolitan PAC Report state (pages 135, 136 and 138 respectively):

> ***Recommendation 2***
>
> *The Panel recommends that the concept of RMZs enunciated in the SCI report be incorporated into a broader risk framework that includes:*
>
> - *Identifying natural features likely to be at risk of negative environmental consequences from subsidence impacts.*
> - *Assessing the potential risk to those features from the mining proposal.*
> - *Identifying the options for dealing with any significant risk.*
> - *Determining which of these options will form part of the management plan.*
> - *Monitoring the subsidence impacts, consequences for the feature, and outcomes from the management strategies.*
> - *Contingency options and planning to deal with exceedances, and*
> - *Auditing of the risk management process.*
>
> ***Recommendation 3***
>
> *The Panel recommends that the steps set out in Section 6.2 of this review for assessing risk be considered for inclusion in future requirements for the assessment of proposals for mining in the Southern Coalfield to ensure that appropriate information on risks to significant natural features is available in the EA.*
>
> ***Recommendation 11***

The Panel recommends that until objective measures or policy guidance are available, adoption of an approach to significance and protection be adopted that is characterised by a case by case assessment of the values attributed to the watercourse, the options for protecting these values and the feasibility and costs of doing so. A suggested set of values is included in Section 7.4.1 of this report.

The Bulli Seam Operations (BSO) PAC report was published in July 2010, following the Metropolitan PAC Report. In regard to the assessment of potential impacts to streams it stated that the significance of the streams was a relevant consideration in regard to the acceptability of potential impacts associated with subsidence:

The SCI Report and the Metropolitan PAC Report describe a process that leads to an assessment of the acceptability of mining risks to the values of natural features. At its simplest, an application of this process to rivers and streams in the BSO Operations Study Area requires:

- *Identification of the value and significance of rivers and streams in the Study Area.*
- *An assessment of the impact of the Project on the value of rivers and streams in terms of likelihood and consequences of impact, including the effect of mitigation and remediation measures.*
- *An assessment of the acceptability of the outcome.*

…

Appendix C and Appendix P of the EA provide detailed descriptions of streams and their attributes. The detailed stream surveys that have mapped, catalogued and photographed streams and stream attributes throughout the Study Area, together with the other information presented in the "stream matrix" (Attachment PB) provide an exemplary data base.

Appendix P goes on to acknowledge the range of use and non use values of the waterways: water supply, ecological significance, conservation value, community value and recreational value are all recognised. However little progress is made in the EA toward interpreting the catalogue of raw data to provide any link to the significance of an individual stream or a collective of streams in a catchment. Furthermore, only a subset of the values appear to be carried forward for assessment of the acceptability of impacts. The difficulty of these steps is acknowledged by the Panel and it is not suggested that any deterministic process can be called upon to deliver incontestable outcomes. However, without an assignment of values to streams or groups of streams, and without consistent appreciation of all the values in the system, it becomes impossible to make an holistic assessment of the risks to those values from mining.

This Stream Risk Assessment has been prepared by Hydro Engineering & Consulting Pty Ltd (HEC) based on data provided by South32, Mine Subsidence Engineering Consultants (MSEC), Cardno (NSW/ACT) Pty Ltd (Cardno) and Niche Environment and Heritage (Niche). It provides:

1. An overview of the framework and approach for assessment in consideration of the Metropolitan PAC Report (Section 2).
2. A summary of mine parameters and potential subsidence impacts (Section 3).
3. Identification and characterisation of streams within the longwall mining area and immediate surrounds (Section 4).
4. Assessment of 'significant' features (Section 5).
5. Identification of risk and assessment of impacts (Section 6).
6. A description of risk management measures and acceptability of impacts (Section 7).

2.0 FRAMEWORK AND ASSESSMENT APPROACH

The risk assessment approach for subsidence impact and environmental consequences in relation to natural features from Section 6.2 of the Metropolitan PAC Report is below:

The following steps are suggested as a means of ensuring that adequate relevant information is available to the decision maker. They should also assist the Proponent and the regulators to focus their attention early on key issues for preparation of proposals and the identification of problems.

Step 1: Identify the mine characteristics and types of subsidence impacts likely to be experienced in the Project Area. Mine characteristics include depth, geology, mining method, mining height, mine layout and percentage extraction.

Step 2: Identify significant natural features that might be at risk from the subsidence impacts that could be expected from the proposal. In the case of the Southern Coalfield, a checklist of features that require consideration could be developed based on the SCI Report. It should include at least rivers and significant streams, upland swamps, endangered ecological communities, threatened species habitat, major cliff lines and Aboriginal Heritage. A full description of these features is required, including any characteristics that may be relevant in assessing potential subsidence-related impacts and consequences for the feature or parts of the feature.

Step 3: Assess any features identified in Step 2 that warrant special significance status[27] in any proposed risk management plan.

Step 4: Using the criteria set out in the SCI Report for deriving RMZ boundaries, draw a Risk Management Zone around those features from Step 2 and Step 3 and assess the risk to the feature (or relevant part of the feature)[28], and

Step 5: Proposed risk management plans will be required:

- *For those features of special significance identified in Step 3 where a risk of impact is a real possibility[29].*
- *For those features identified in Step 2 where a risk of significant impact is a real possibility[30].*

Risk management plans should identify:

i. the options for managing the risk based on one or a combination of avoidance, mitigation, remediation or tolerance and taking account of any assessment of special significance of the feature;
ii. where relevant, the potential costs of those options;
iii. a preferred option;
iv. where relevant, a monitoring regime that will detect impact, measure actual impact against predicted impact and measure the effectiveness of the management strategies adopted;
v. contingency plans for dealing with the situation where actual impact exceeds predicted impact; and
vi. auditing of the implementation and effectiveness of the risk management plan.

27 *'Special Significance Status' is based on an assessment of a natural feature that determines the feature to be so special that it warrants a level of consideration (and possibly protection) well beyond that accorded to others of its kind. It may be based on a rigorous assessment of scientific importance, archaeological and cultural importance, uniqueness, meeting a statutory threshold or some other identifiable value or combination of values.*

28 *The Panel notes that it would be desirable to develop a two-stage risk assessment process for Step 4 to ensure that those features from steps 2 and 3 that are unlikely to meet the risk and impact thresholds in Step 5 are not required to undergo a stage 2 detailed risk assessment.*

29 *'Real Possibility' in this context means that the risk of occurrence needs to be more than remote, but not so high as to require a finding of 'more likely than not'. A risk of occurrence of between 5 and 15 percent is probably an appropriate starting point for consideration.*

30 *A lower level of acceptable impact will apply to features of special significance and the threshold for requiring preparation of a risk management plan will therefore also be lower.*

The framework and assessment approach to streams has been conducted consistent with the steps in Section 6.2 of the Metropolitan PAC Report described above, as well as in consideration of the Bulli Seam Operations PAC Report. Table 1 shows the suggested approach has been incorporated in this Stream Risk Assessment.

Table 1 Risk Assessment Approach

Metropolitan PAC Report Section 6.2	Stream Risk Assessment
Step 1: *Identify the mine characteristics and types of subsidence impacts likely to be experienced in the Project Area. Mine characteristics include depth, geology, mining method, mining height, mine layout and percentage extraction.* …	A summary of mine parameters and potential subsidence impacts is provided in Section 3.
Step 2: *Identify significant natural features that might be at risk from the subsidence impacts that could be expected from the proposal. In the case of the Southern Coalfield, a checklist of features that require consideration could be developed based on the SCI Report. It should include at least rivers and significant streams, upland swamps, endangered ecological communities, threatened species habitat, major cliff lines and Aboriginal Heritage. A full description of these features is required, including any characteristics that may be relevant in assessing potential subsidence-related impacts and consequences for the feature or parts of the feature.* …	Identification and characterisation of streams within the longwall mining area and immediate surrounds is provided in Section 4.
Step 3: *Assess any features identified in Step 2 that warrant special significance status27 in any proposed risk management plan.* …	Assessment of 'significant' features is provided in Section 5.
Step 4: *Using the criteria set out in the SCI Report for deriving RMZ boundaries, draw a Risk Management Zone around those features from Step 2 and Step 3 and assess the risk to the feature (or relevant part of the feature)28, and* …	Identification of risk and assessment of impacts is provided in Section 6.
Step 5: *Proposed risk management plans will be required:* …	A description of risk management measures and acceptability of impacts is provided in Section 7.

3.0 STEP 1: MINE PARAMETERS AND LIKELY TYPES OF SUBSIDENCE IMPACTS

The Project mine parameters (depth, geology, mining method, mining height, mine layout and percentage extraction) and likely types of subsidence impacts are described below. Further detail is provided in Appendix A of the EIS (MSEC, 2019).

3.1 MINE PARAMETERS

3.1.1 Mine Layout

The Project general arrangement is shown on Figure 3-3 in the Main Report of the EIS. The Project extent of longwall mining area has been divided into two domains: Area 5 and Area 6.

3.1.2 Geology

The Project is located in the southern part of the Sydney Basin. The geology mainly comprises sedimentary sandstones, shales and claystones of the Permian and Triassic Periods, which have been intruded by igneous sills. The major sedimentary units are, from the top down, the Hawkesbury Sandstone, the Narrabeen Group sandstone, siltstone and claystone and the Illawarra Coal Measures. The Wianamatta Group shale is only present as a very limited residual in localised areas.

There is a north-east to south-west trending fault at seam level that crosses the proposed Longwall 501 to Longwall 508B and Longwall 513 to Longwall 516. A north-west to south-east trending dyke also extends through the proposed Longwall 508A and Longwall 509. The locations of these known and inferred structures in the vicinity of the Project extent of longwall mining areas are provided in Appendix A of the EIS.

3.1.3 Mining Method

Longwall mining utilises a shearer to cut a slice of coal from the coal face (generally up to 1 m thick) and the broken coal is then transferred to the coal conveyors via an armoured face conveyor. Longwall mining utilises a series of hydraulic roof supports to provide a working area for the shearer and the machine operators. Once each slice of coal is removed from the longwall face, the hydraulic roof supports are moved forward, allowing the roof and a section of the overlying strata to collapse behind the longwall miner (referred to as forming the 'goaf'). In order to start each new panel, the longwall miner is separated into components and re-assembled in the installation roadway of the next panel.

3.1.4 Depth/Mining Height

Proposed longwall panels in Area 5 target the Bulli Seam which has a thickness between 2.1 m and 3.2 m and a mining height of 2.5 m to 3.2 m. The depths of cover above the proposed longwall panels in Area 5 vary between a minimum of 250 m in the southern part of the mining area and a maximum of 390 m in the north-eastern part of the mining area. The average depth of cover within the mining area is 360 m.

Proposed longwall panels in Area 6 target the Wongawilli Seam which has a nominal thickness of 10 m and a mining height of 3.9 m. The depths of cover above the proposed longwall panels in Area 6 vary between a minimum of 375 m in the south-western part of the mining area and a maximum of 460 m in the north-eastern part of the mining area. The average depth of cover within the mining area is 440 m.

3.1.5 Percentage Extraction

In Area 5, the Bulli Seam varies from 2.1 m and 3.2 m in thickness within the Project extent of longwall mining area and it is expected that its full thickness would be extracted during the Project underground operations.

In Area 6, the Wongawilli Seam thickness is approximately 10 m however a mining height of 3.9 m is proposed in the lower portion of the seam.

3.2 LIKELY TYPES OF SUBSIDENCE IMPACTS

Longwall mining results in subsidence movements at the surface above and adjacent to longwall mining activities. These movements and the resulting patterns of fractures at the surface have been described in the Subsidence Assessment (Appendix A of the EIS). The types of subsidence effects that can cause impacts and environmental consequences to surface water resources have been identified as follows:

- Vertical (downward) and horizontal displacements of the surface which are referred to as **vertical subsidence** and **horizontal subsidence**.
- Changes in surface slope, which is referred to as **tilt**.
- The rate of change of tilt, which is referred to as **curvature**.
- Changes in the horizontal distance between two points on the surface which is referred to as **tensile strain** if the distance between the two points increases and **compressive strain** is the distance between the two points decreases.
- **Horizontal shear deformation** across monitoring lines can be described by various parameters including horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index.

Far-field movements are horizontal movements located beyond the longwall goaf edges and over solid unmined coal areas, which tend to be bodily movements towards the extracted goaf area and are accompanied by very low-levels of strain. These movements generally do not result in impacts on natural features or built environments, except where they are experienced by large structures which are sensitive to differential horizontal movements.

In addition to the above systematic (or conventional) effects, there are also particular effects which occur in incised valleys and gorges typical of the Southern Coalfield which are referred to as non-systematic (or un-conventional) effects. These include the following:

- **Upsidence** is the reduced downward subsidence, or the relative uplift within a valley which results from the dilation or buckling of near surface strata at or near the base of the valley.
- **Valley closure** is the reduction in the horizontal distance between the valley sides.
- **Compressive valley strains** occur within the bases of valleys as the results of valley closure and upsidence movements. **Tensile valley strains** also occur at the tops of the valleys as the results of valley closure movements.

4.0 STEP 2: IDENTIFICATION AND CHARACTERISATION OF STREAMS

The identification and characterisation of streams described below is based on desktop analysis and site inspections (by South32 and others). Stream mapping is provided in Attachment 1. Site inspections were also conducted for a representative sample of streams in the Project area by various specialists to inform the EIS studies including MSEC, Niche and Cardno (refer to Appendices A, D, and E of the EIS respectively). It is recognised that there are limitations associated with the assessment of each of the characteristics considered. Notwithstanding, the information provided is considered suitable for the purpose of the stream risk assessment.

4.1 IDENTIFICATION OF STREAMS

The SCPR recommended that EISs for project applications lodged under the EP&A Act identify and assess significant natural features located within 600 m of the edge of secondary extraction (Figure 1) (SCPR Recommendation 4).

The Study Area has been defined as the surface area that could be affected by the mining of the proposed longwalls in Areas 5 and 6. The extent of the Study Area has been calculated by combining the areas bounded by the following limits:

- the extent of longwall mining, taken as the 35° angle of draw boundary from the extents of the proposed longwalls in Areas 5 and 6;
- the predicted limit of vertical subsidence, taken as the 20 mm subsidence contour, resulting from the extraction of the proposed longwalls; and
- the natural features located within 600 m of the extent of the longwall mining area.

The definition of the Study Area has been an iterative process. The extents of proposed longwalls in Areas 5 and 6 have been informed by the outcomes of this Stream Risk Assessment, along with other legislative and geological factors, such as the extent of CCL 768 and extent of economically recoverable coal reserves. In addition, proximity of the longwalls to water supply infrastructure has also informed longwall mining constraints (i.e. proposed longwall setbacks of 1,000 m from the Avon and Cordeaux Dam walls and 300 m from the Avon and Cordeaux Full Supply Levels).

In relation to significant watercourses, the SCPR states:

> *The Southern Coalfield's significant natural features include rivers and higher order streams,…*

and

> *RMZs for watercourses should be applied to all streams of 3rd order or above, in the Strahler stream classification.*

The Stream Risk Matrix (Attachment 2) includes relevant rivers identified within the Study Area as named on the Bargo, Bulli, Avon River and Wollongong 1:25,000 scale topographic mapping sheets (Department of Finance, Services and Innovation, 2018) consistent with the SCPR and has conservatively identified streams of second order or above according to the Strahler stream classification system (also shown on Figure 1).

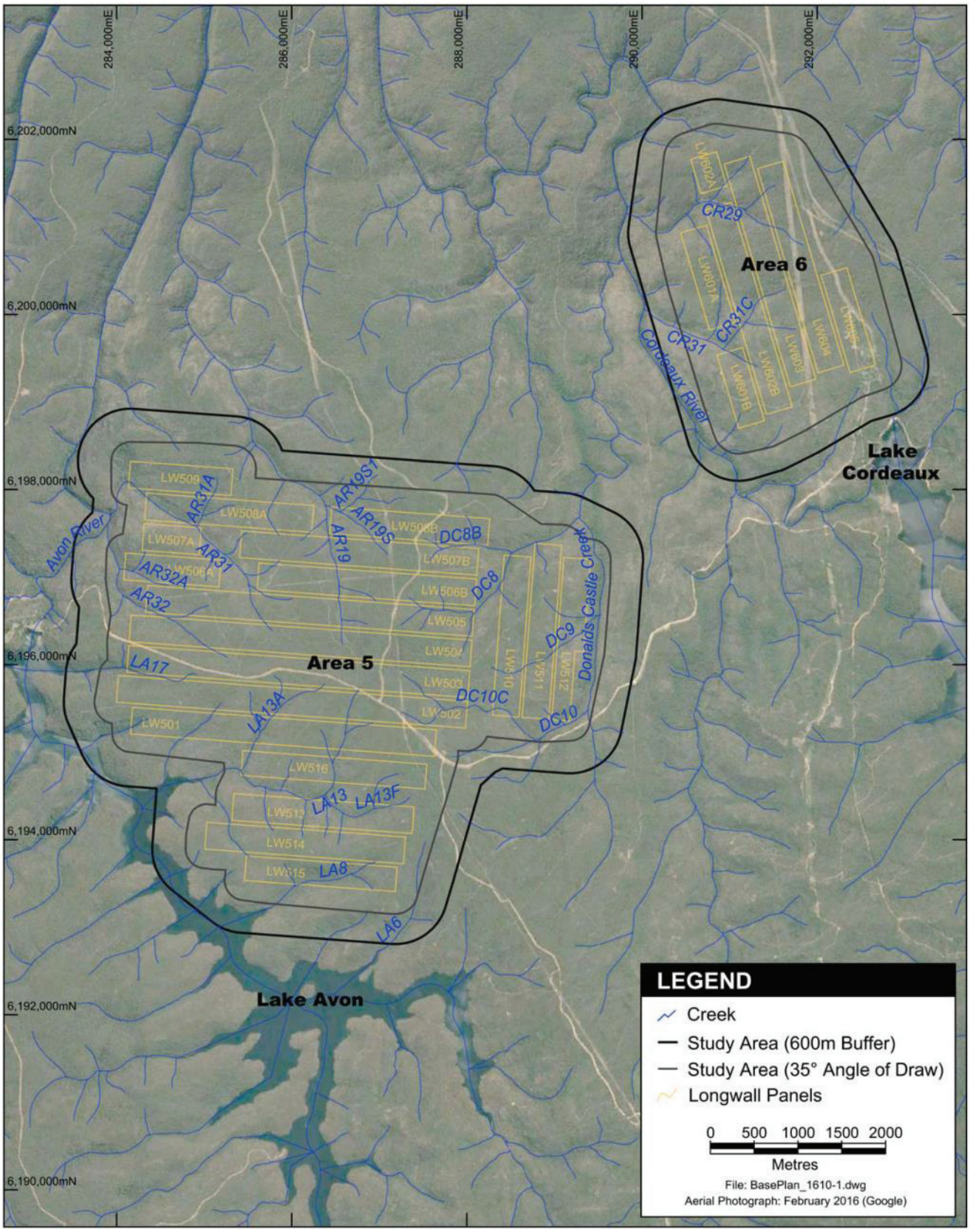

Figure 1 Streams of Second Order or Above Identified within the Study Area (600 m Buffer)

Rivers and streams of second order or above (herein referred to as streams) have been identified (Figure 1 and Attachment 2). Each stream identified is listed in Attachment 2 and their locations are also shown in Attachment 3. The characteristics of each stream reach are summarised in the sections below from Attachments 1 and 2.

4.2 TOPOGRAPHIC CHARACTERISTICS

4.2.1 Stream Order

The maximum order of each stream reach according to the Strahler stream classification system has been identified and provided in Attachment 2. Streams classified lower than second order are included on the basis that they are named rivers or the stream is located within the 600 m boundary of the extent of the longwall mining area and comprises some reaches of second order or above.

4.2.2 Average Stream Gradient

The average stream gradient was determined for each stream reach by calculating the change in elevation over the relevant reach and dividing by the length of the reach. The average stream gradient ranges from 2 metre per kilometre (m/km) to 146 m/km (Attachment 2). In summary, 14 reaches have an average stream gradient greater than 40 m/km. The ranges of delineated average stream gradients are presented in Figure 2.

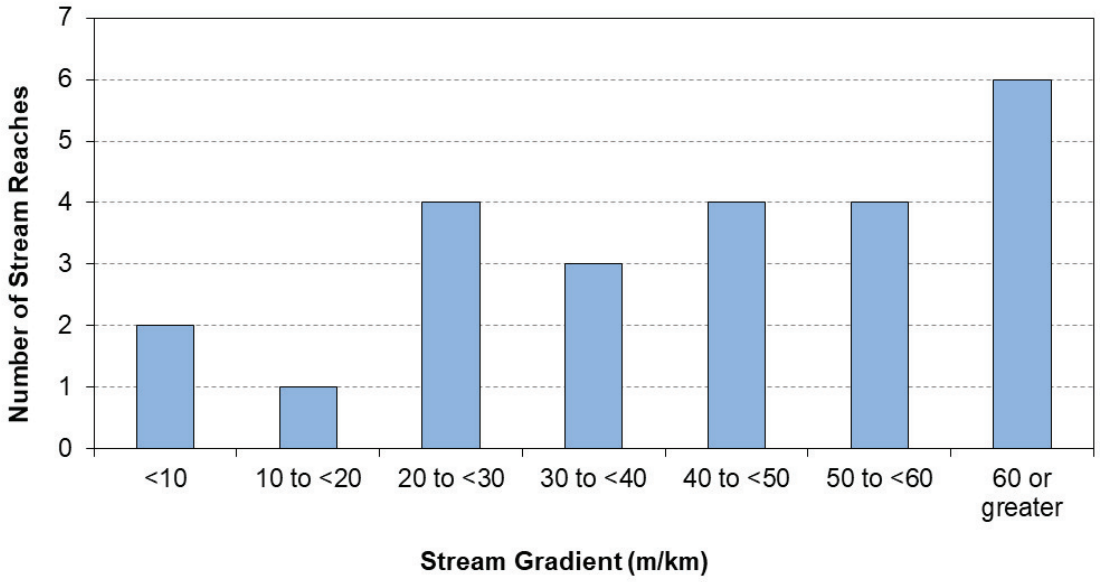

Figure 2 Distribution of Stream Gradients

4.2.3 Geomorphic Type

A geomorphic classification has been developed by HEC to characterise the geomorphic attributes of the streams. The classification scheme has been based loosely on the River Styles framework as described in the paper by Brierley et al. (2002) and is considered to be indicative only.

The classification scheme is based on four groups of geomorphic attributes:

1. Valley type – confined, partially confined and alluvial.
2. Floodplain development – no floodplains, irregular floodplain and floodplain pockets less than 25% of stream fringed by floodplains; moderate floodplain development – between 25% and 75% of stream fringed by floodplains; high floodplain development – greater than 75% of stream fringed by floodplains.
3. Bed materials and mobility – bedrock comprising rock outcrop or boulderfield beds with no or minimal/infrequent mobile sediments in some sections; sand bed comprising cohesionless sandy sediments; cohesive bed comprising silty, sandy bed materials with significant cohesion and/or organic materials.

4. Physical features – pools and rockbars and chutes; cascades and waterfalls; boulderfields; pools and riffles in alluvial/mobile streams; uniform streams with no or insignificant pool development; swamps and/or chain of ponds wide shallow streams with significant in-stream vegetation and persistent swamps or wide shallow pools with ill-defined channels.

In applying the classification scheme to the stream reaches, the classification which is dominant over the full length of the stream reach has been selected.

The geomorphic attributes of the stream reaches are classified in Attachment 2.

4.2.4 In-Stream/Visual Amenity Features

Stream mapping undertaken by South32 has identified in-stream/visual amenity features including rockbars, waterfalls, pools, riffles and boulderfields. Features identified are included in Attachment 2 and shown on the stream mapping provided in Attachment 1.

4.3 HYDROLOGIC CHARACTERISTICS

4.3.1 Stream Catchment Area

Stream catchment areas have been delineated and calculated by HEC for each of the stream reaches and are provided in Attachment 2. The catchment areas are based on the total upstream catchment area reporting to the downstream point of each stream reach[1].

In summary, 83% of the stream reaches have a catchment area of less than 5 square kilometres (km^2) (Attachment 2). Four have a catchment area of greater than 5 km^2 (Attachment 2). The two reaches with the largest catchment areas are the Cordeaux River (135.5 km^2) and the Avon River (150.4 km^2) (Attachment 2). The ranges of delineated stream reach catchment areas are presented in Figure 3.

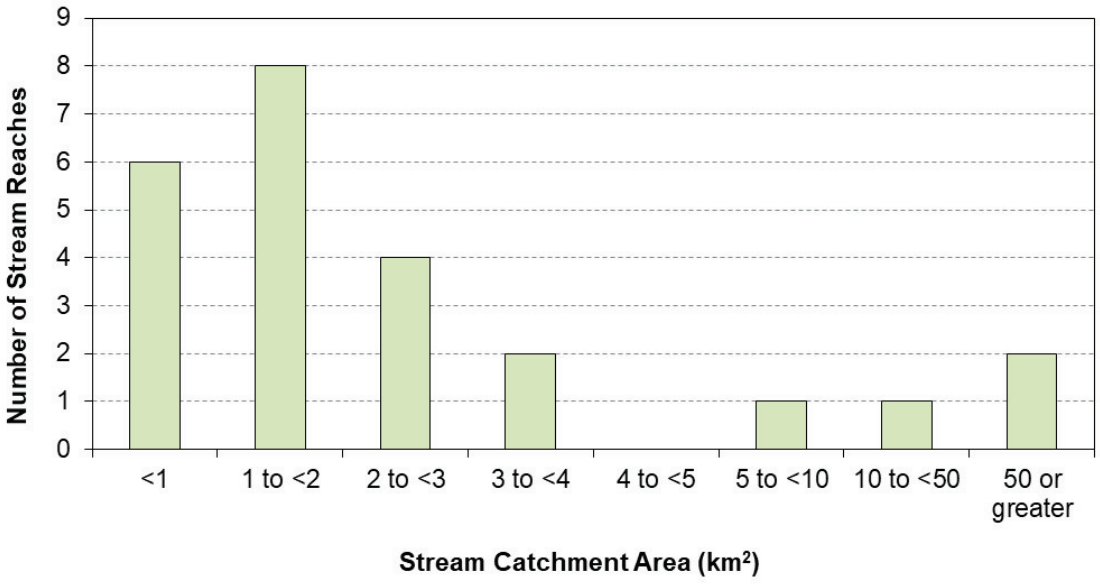

Figure 3 Distribution of Catchment Areas

[1] Where the stream reach extends more than 600 m of the extent of the longwall mining area the end of the reach is taken at the 600 m boundary. Where the stream terminates at another stream within 600 m of the extent of the longwall mining area the end of the reach is taken at the stream confluence.

4.3.2 Permanence of Flow

The permanence of flow of each stream reach has been categorised in Attachment 2 as:

a) perennial;
b) intermittent and/or ephemeral; or
c) perennial – intermittent/ephemeral (if the permanence of flow changes over the stream reach being assessed).

Streams were categorised as perennial based on the mapping of perennial watercourses on 1:25,000 scale topographic mapping sheets (Department of Finance, Services and Innovation, 2018). Streams not mapped as perennial were categorised as intermittent and/or ephemeral.

In summary, two stream reaches were categorised as perennial and the remaining reaches as intermittent and/or ephemeral (Attachment 2). The two perennial reaches are the Cordeaux River and Avon River where streamflow is regulated by releases from upstream dams.

4.3.3 Stream Regulation History

Natural flows in many Australian streams have been regulated or altered, for example, through the extraction of water, the construction of dams and weirs and discharges into streams.

Attachment 2 identifies streams that have been regulated by WaterNSW-controlled dams known to be situated upstream of the stream reaches (i.e. Cordeaux River and Avon River reaches).

4.3.4 Importance to Catchment Yield

The importance of each stream reach to catchment yield has been assessed as a percentage of the reach's contribution relative to the overall area of the closest parent watercourse in Attachment 2. The parent watercourses are the Avon River, Donalds Castle Creek, Lake Avon and the Cordeaux River. In summary, approximately half of the individual reaches were assessed as making up less than 1% of the catchment area of the closest parent watercourse (Attachment 2).

4.3.5 Upland Swamps

Upland swamps are located within the catchments of the streams considered in this Stream Risk Assessment and a full description of the location and potential impacts to these swamps is provided in the Surface Water Assessment (Appendix C of the EIS; HEC 2019) and the Biodiversity Assessment (Appendix D of the EIS; Niche 2018).

4.4 ECOLOGICAL SIGNIFICANCE

4.4.1 Environmental Quality (Observed/Existing Disturbance)

Attachment 2 presents an assessment of the environmental quality of the stream reaches as either pristine, modified or severely modified based on the following:

- Pristine – majority of vegetation within upstream catchment is intact, limited disturbances within catchment area (e.g. fire tracks, exploration activities).
- Modified – majority of riparian vegetation intact, agricultural/other disturbances within catchment areas.
- Severely Modified – moderate to high disturbance of riparian vegetation, agricultural/other disturbances to catchment area and/or disturbance to channel/flow (e.g. weirs, dams, discharges).

This qualitative assessment has been made in consideration of the information provided in the Surface Water Assessment (Appendix C of the EIS) and the Biodiversity Assessment (Appendix D of the EIS) and the inspection of aerial photographs provided in Attachment 3.

In summary, all reaches were assessed as being pristine, as opposed to modified or severely modified as they are generally undisturbed areas located within the Metropolitan Special Area, hence public access is restricted by WaterNSW (Attachment 2).

4.4.2 Flora and Fauna Surveys

Aquatic and terrestrial flora and fauna surveys have been conducted for the Project and these surveys included representative sampling of stream and adjacent riparian and/or gully habitats. Flora and fauna sites surveyed relevant to the list of streams are provided in Attachment 2. Details of the survey methodologies are provided in the Aquatic Ecology Assessment (Appendix E of the EIS, Cardno 2018) and Biodiversity Assessment (Appendix D of the EIS).

A number of aquatic and terrestrial flora and fauna surveys and reports have been conducted in recent years in the general locality of the Project and were reviewed as part of the surveys and assessments (Appendix D and E of the EIS). This information has also informed the assessment of the ecological significance of the streams.

4.4.3 Key Fish Habitat

Key Fish Habitat (KFH) mapping for Wollongong is available on the NSW DPI website and indicates that the Avon River and Cordeaux River are KFH (NSW DPI 2017). Donalds Castle Creek and the drainage lines that traverse the Study Area are not identified as KFH in the DPI mapping.

However, the occurrence of sensitive fish habitat in the Study Area, and in particular, Donalds Castle Creek and drainage lines, was assessed using the criteria in NSW DPI (2013) relevant to freshwater habitat (Appendix E of the EIS).

Mapping was done initially as a desktop exercise, with ground-truthing undertaken in the majority of waterways during September and December 2016. Donalds Castle Creek was identified as providing some Type 1 ('Highly sensitive') KFH, with the lower, third order reaches of some streams providing Type 2 ('Moderately sensitive') KFH.

4.4.4 Endangered Ecological Communities

Some vegetation communities mapped along streams (Appendix D of the EIS) represent Endangered Ecological Communities listed under the NSW Biodiversity Conservation Act, 2016 (BC Act) and/or Commonwealth Environment Protection and Biodiversity Conservation Act, 1999 (EPBC Act). This includes vegetation mapped as Upland Swamp: Restiod Heath, Upland Swamp Cyperoid Heath, Upland Swamp: Tea-Tree Thicket, and Upland Swamp: Banksia Thicket.

Based on the mapping provided in Appendix D of the EIS, these communities have all been conservatively included in Attachment 2 as being associated with streams. However, Appendix D of the EIS notes that the EECs are not true riparian communities in that they do not rely on water from streams.

4.4.5 Threatened Species Records

Threatened flora and fauna records for each stream and adjacent riparian and/or gully habitats have been identified and provided in Attachment 2. The records of threatened species are based on the results of the Aquatic Ecology Assessment (Appendix E of the EIS) and the Biodiversity Assessment (Appendix D of the EIS).

In summary, five threatened species were identified by the Project surveys or are known aquatic fauna records for the area as reported in Appendix E of the EIS. Notwithstanding these records, it is recognised that all streams and adjacent riparian and/or gully habitats in the Project area provide potential habitat for a range of threatened species.

4.5 ASSOCIATED LANDUSE

The Project area is located within the WaterNSW Metropolitan Special Area and therefore all streams identified in the Study Area are located within the Metropolitan Special Area, access to which is controlled by WaterNSW. The associated land zoning is water catchment for all streams identified in the Study Area and there is no public access.

The Metropolitan Special Area is covered by the Sydney Drinking Water Catchment State Environmental Planning Policy (Sydney Drinking Water Catchment State Environment Planning Policy [SEPP]) which commenced on 1 March 2011. The Sydney Drinking Water Catchment SEPP applies to land within the Sydney drinking water catchment, which comprises a number of sub-catchments which contribute to Sydney's (and surrounding regional centres) water supply, including the Upper Nepean River.

4.6 COMMUNITY VALUE

While the stream reaches are generally inaccessible to the public, being situated in the WaterNSW Metropolitan Special Area (Attachment 2) the stream reaches provide community value for their contribution to Sydney's drinking water supply (refer Section 4.5).

4.7 RECREATIONAL VALUE

All stream reaches are generally inaccessible to the public being situated in the WaterNSW Metropolitan Special Area (Attachment 2) hence there is no opportunity for recreational value.

4.8 ABORIGINAL HERITAGE

Aboriginal heritage items have been identified in the Study Area and a full description of identified sites and potential impacts is provided in the Aboriginal Cultural Heritage Assessment (Appendix F of the EIS; Niche, 2019).

4.9 STREAM PHOTOS

A catalogue of example photos of streams has been compiled from stream surveys and inspections and is provided in Attachment 3.

5.0 STEP 3: ASSESSMENT OF FEATURES THAT WARRANT SPECIAL SIGNIFICANCE STATUS

Of the streams in the Study Area, the most significant in terms of stream order, catchment area, importance to catchment yield, permanence of flow, mapped KFH and function as a regulated watercourse for drinking water supply are the Avon River and the Cordeaux River (i.e. downstream of the Avon and Cordeaux Dams, respectively).

The next most significant stream in terms of stream order, catchment area, KFH and importance to catchment yield is Donalds Castle Creek. However, this stream is not considered to be perennial and is not a regulated watercourse for water supply.

The remaining unnamed streams are lower order, ephemeral, have low importance to catchment yield and are not regulated watercourses. While third order sections of these streams are considered to potentially contain Type 2 ('Moderately sensitive') KFH, streams of this type are common throughout the catchment area (Appendix E of the EIS).

Within these unnamed, ephemeral streams, it was identified by South32 through site inspection that particular stream features, i.e. pools and steps, were more 'significant' than other stream features. As such, stream features meeting the following definition have been classified by South32 as 'key stream features':

- Pools with > 100 m^3 and holding water.
- Steps with > 5 m height with a permanent pool at the base.

A summary of the key stream features identified along streams of second order or above that met this criterion is shown in Table 2.

Table 2 Summary of Key Stream Features

Stream	Features Identified as Key Stream Features
AR19	13 pools
AR31	4 pools, 1 waterfall
AR32	3 pools, 3 steps
LA13	4 pools
DCC	12 pools
DC10C	1 pool
DC8	2 pools, 2 steps, 1 rockbar
CR29	4 pools
CR31	8 pools

An assessment of the significance of streams with respect to the presence of upland swamps and threatened flora/fauna records is provided in Appendix D of the EIS, along with measures to avoid, minimise and offset potential impacts.

6.0 STEP 4: RISK IDENTIFICATION AND ASSESSMENT

6.1 LONGWALL LAYOUT DESIGN OBJECTIVES

In consideration of the relative significance of the Avon and Cordeaux Rivers and Donalds Castle Creek, and consistent with existing South32 commitments, longwall mining would be set back from these named watercourses to achieve 200 mm additional predicted closure or less. Appendix A of the EIS notes that there is a low probability (less than 10%) of pool flow diversion and pool water level impacts observed where the predicted total valley closure was less than 200 mm.

Longwall mining would also be set back from the key stream features identified by field investigations on the unnamed ephemeral drainage lines within the Study Area to reduce the likelihood of subsidence impacts to these features, as follows:

- 50 m setback from the key stream feature to the ends of the longwall (where there is no longwall mining on any other side of the stream feature).
- 100 m setback from the key stream feature to the longwall (where mining is to occur on two or more sides of the stream feature).

The key stream feature setbacks above have been incorporated into the longwall layout developed by South32 to reduce potential subsidence impacts to these features, based on previous mining experience in Dendrobium Mine Areas 2 and 3. As discussed in the Subsidence Assessment (MSEC, 2019) for the Project, potential subsidence effects are reduced when stream features are not directly undermined.

For key stream features that were already located outside of these setback distances, or had already been offset through other longwall setbacks (e.g. setbacks from named streams to achieve 200 mm or less additional predicted closure) no additional longwall setbacks were required. In addition, the key stream feature setbacks developed have also resulted in a number of other stream features (i.e. those not identified as 'key' stream features) and stream lengths to not be directly undermined, hence reducing potential subsidence effects to these natural features.

Further information regarding the key stream features can be found in the Stream Risk Matrix (Attachment 2).

6.2 SYSTEMATIC AND NON-SYSTEMATIC SUBSIDENCE PREDICTIONS

Systematic and non-systematic subsidence predictions (refer Section 3.2) for each stream based on the EIS Base Plan Longwalls are provided in Attachment 2. The subsidence and tilt predictions for each stream are illustrated on the longitudinal sections in Attachment 6.

The total maximum subsidence and tilt predictions are used to inform and assess the potential risk of subsidence impacts and associated environmental consequences on streams in Section 6.3.

The method for calculation of upsidence and closure is closely related to the equivalent valley height for each stream. As a result, streams located in more incised valleys are generally subject to more upsidence and closure movements than a stream located in a broader valley. The maximum equivalent valley heights (MEVHs) for each stream (based on the stream long section) are provided in Attachment 2. There is inherent conservatism included in the calculation by using the MEVH, as the equivalent valley height typically varies along the stream.

The change in equivalent valley height and the MEVH along each stream long section, and associated predicted upsidence and closure movements, are illustrated on long sections in Attachment 6.

The above maximum predicted upsidence and closure movements are used to inform and assess the potential risk of subsidence impacts and associated environmental consequences on streams in Section 6.3.

6.3 RISK OF IMPACT RESULTING IN ENVIRONMENTAL CONSEQUENCES

The Subsidence Assessment (Appendix A of the EIS) includes a database of pool and rockbar sites that have experienced mining induced upsidence and valley closure movements in the Southern Coalfield. Appendix A of the EIS notes that there is a low probability (less than 10%) of pool flow diversion and pool water level impacts observed where the predicted total valley closure was less than 200 mm.

Attachment 2 indicates the length of each stream reach predicted to experience greater than 200 mm closure.

Watercourses where sufficient valley closure occurs would experience dilation fracturing, shearing of rock strata and development of a fracture network beneath the stream bed (Appendix C of the EIS). This would likely result in the diversion of a portion of stream flow via the fracture network and a reduction in water level in pools as they drain via hydraulic connections with the fracture network. There is also likely to be reduced continuity of flow between affected pools during dry weather. The capacity of the fracture networks to convey flows via the subsurface network is unknown and may result in decreased flows in streams. Where the stream is experiencing low flow conditions it is likely that a higher proportion or all of the surface flow would be re-directed into the fractured strata.

6.3.1 Typical Environmental Consequences for Streams in Incised Valleys in Hawkesbury Sandstone Areas

In the Hawkesbury Sandstone areas, streams in plateau areas are typically open, dish-shaped drainage lines with ill-defined beds and banks. Upland swamps frequently occur within these areas often culminating at a low rockbar, step or shelf. Further downstream, the streams typically plunge via a series of drops and waterfalls into the incised sections in the deeper valleys. The character of the streams changes with the confined incised valleys and gorges which make up the dissected plateau areas into a series of rockbars, pools and boulder strewn reaches. The beds of the streams in these reaches are dominated by hard exposed rock with loose alluvium limited to the longer and deeper pools where flow energy is lower. Significant rainfall events result in rapid, ‘flashy’ runoff which results in highly turbulent, shallow flows with high velocity particularly over and downstream of rockbars. Velocities would reduce in the deeper longer pools which would act as sediment traps.

Where subsidence and in particular valley closure and upsidence in the streams formed in the Hawkesbury Sandstone is sufficient to cause fracturing of rockbars and development of dilation and cracking along the prominent drainage lines, the following environmental consequences are expected (Appendix A and C of the EIS):

- diversion of a portion of stream flow along the stream length via the created fracture network;
- re-emergence of a portion of the surface flow downstream of the affected area;
- reduced frequency of pools overflowing and lower pool water levels particularly during dry weather;
- reduced and periodic loss of interconnection between pools, particularly during dry weather;
- small changes in bed gradients and limited potential for scouring at locations where tilts considerably increase the natural pre-mining stream gradients;
- localised and transient increases in iron concentrations and other minerals due to flushing from freshly exposed fractures in the sandstone rocks and increased groundwater flows;

- creation and/or enhancement of existing iron rich springs; and
- drainage of strata gas[2].

The primary environmental consequences described above have the potential to result in secondary consequences, such as impacts on the ecological and aesthetic condition of waterways, mainly through diversion of surface flow and reduced water quality.

Over time, fracture networks are likely to at least partially fill with sediment leading to some natural restoration of previously diverted underflow.

6.3.2 Environmental Consequences of Subsidence on Water Supply Quantity

The risk of the quantity of water reaching the Avon Dam and Pheasants Nest Weir being reduced as a consequence of subsidence-induced cracking has been assessed in Appendix C of the EIS, with the reduction to total catchment yields expected to be negligible (i.e. less than 1% of yields to the Avon Dam and Pheasants Nest Weir).

6.3.3 Environmental Consequences of Subsidence on Water Supply Quality

Potential impacts on water quality as a result of the Project subsidence impacts would be localised. Although mine subsidence effects can result in isolated, episodic pulses in iron, manganese, aluminium, other metals and electrical conductivity, there have been no reports of any measurable effect on water quality in downstream reservoirs (Appendix C of the EIS). Water quality as a result of the Project is not expected to impact on the performance of the Avon Dam, the Cordeaux Dam or the Pheasants Nest Weir.

South32 proposes to remediate those stream features identified as key stream features, where subsidence has resulted in physical damage (e.g. significant fracturing of rockbars that results in surface flow diversion and draining of pools). The rockbars classified as key stream features are shown on the stream mapping provided in Attachment 1 and are listed in Attachment 2. As a result, the degree of impact on water quality as a result of the Project would likely be limited in time.

In addition, South32 has committed to water quality improvement actions such that the Project would result in a net neutral or beneficial effect on water quality in the Metropolitan Special Area.

[2] Release of methane-rich strata gases from overburden sequences above the coal seam.

7.0 STEP 5: RISK MANAGEMENT PLANS AND ACCEPTABILITY OF ENVIRONMENTAL CONSEQUENCES

7.1 MONITORING AND MANAGEMENT

South32 has been undertaking baseline surface water monitoring within and adjacent to Area 5 and Area 6. It is recommended that this monitoring be continued and expanded upon as detailed in Table 3.

Monitoring locations would be confirmed as part of the Extraction Plan process, along with performance measures and contingency measures.

It is recommended that monitoring should continue for at least two years following mining to confirm performance measures are being achieved or until the completion of successful remediation/restoration activities.

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Table 3 Stream Monitoring Programme Overview

Parameter	Monitoring Sites	Description
Water Level/Flow		
Surface water flow rate	Existing rated gauging stations (refer Figure 6 in Appendix C of the EIS): • LA4S1 • DCU • DC13S1 • DCS2 Existing water level monitoring stations: • AR31S1 • AR32S1 • LA13AS1 • LA13S1 • AR19S1 • DC8S1 • CR29S1 • CR31S1 Plus rated gauging stations at three control catchment sites (catchments located outside mine-affected areas)	• The mine area specific flow monitoring would be progressively developed over the Project life • Water level monitoring stations should be converted to rated gauging stations at least two years prior to the commencement of longwall mining within each catchment. • Gauging stations should provide suitable minimum low flow resolution and accuracy. Interim targets of ± 0.0025 ML/d resolution and ± 10% accuracy in flow rate over the flow range 0.01 to 10 ML/d are proposed. • Flow monitoring would contribute to the quantitative understanding of the pre-mine catchment via the use of baseline streamflow models, identify the need for remediation and inform the success criteria for remediation works. The data would be used for ongoing calibration of stream catchment/flow models and the assessment of impacts by comparison to the pre-mine models. • Additional pluviometers should be established within the catchment of either creek AR31 or AR19 and the control catchments to provide reliable rainfall information required to interpret and model the dynamics of catchments. • An automatic weather station monitoring temperature, humidity, wind speed, wind direction and solar radiation on at least an hourly basis should be established between Areas 5 and 6 in order to allow monitoring of evaporation rates (by calculation). • Periodic (monthly during flow) manual flow gauging should be undertaken to verify adopted rating curves.
Swamp water level	Existing sites plus three control sites to be located outside the area of mining	• Continuous data collected by sensors/loggers in shallow bores and soil moisture monitoring. • Data should be reviewed every 3 months to ensure consistency/accuracy. • The data would for used for ongoing calibration of swamp catchment/flow models, the assessment of impacts by comparison to the pre-mine models, the need for and subsequent success of remedial works.

Table 3 Stream Monitoring Programme Overview (cont.)

Parameter	Monitoring Sites	Description
Water Level/Flow (cont.)		
Swamp flow rate	Suitable sites (to be selected by field reconnaissance)	• Where surface outflows at the downstream end of the swamp are sufficiently concentrated to enable flow to be reliability measured, a low flow monitoring station (such as an instrumented V notch weir or flume) should be established. • The data would for used for ongoing calibration of swamp catchment/flow models, the assessment of impacts by comparison to the pre-mine models, the need for and subsequent success of remedial works.
Pool water level	Pools associated with Key Stream Features identified by South32 plus four additional pools as 'controls' in areas outside the effects of mining and with similar morphology	• Continuous data collected by water levels sensors/loggers in at least half of the significant pools plus the four control pools, with levels recorded to AHD. • Manual water level measurements to confirm sensor data. • Manual monitoring of the remaining pools' water levels with levels recorded to AHD. • Data to be reviewed every 3 months to ensure consistency/accuracy. • Data to be used (during mining) to identify the need for and subsequent success of remedial works.
Water Quality		
Surface water quality	Existing sites	• The mine area specific water quality monitoring should be further developed progressively ahead of Project commencement. • Water quality monitoring should provide at least two years of data prior to the commencement of extraction within each catchment. • Sampling should be undertaken on at least a monthly sampling frequency, flow permitting (intensity may be increased during periods of subsidence or changes in monitored water quality). • Water samples should be analysed by an appropriately accredited laboratory for the standard suite of parameters used by Illawarra Coal in their existing monitoring program. • Data collected during mining should be compared to baseline data to identify changes to water quality which indicate potential water quality impacts due to mining.

Table 3 Stream Monitoring Programme Overview (cont.)

Parameter	Monitoring Sites	Description
Appearance		
Observational and photographic monitoring	All flow and quality monitoring sites	Visual signs of impacts on creeks and drainage lines (i.e. cracking, vegetation changes, increased erosion, changes in water colour, development of iron floc, etc.): • Monthly monitoring during mining and subsidence. • Weekly when longwall is within 400 m of site.
Remediation		
Stream (Pool) remediation	At sites on rivers stream reaches where remediation works have been implemented.	A programme should be developed to monitor the performance of the remediation works implemented for the Project as part of a remediation planning and approval. The plan would include specific success criteria to be informed by monitoring Examples of the type of monitoring parameters relevant to this programme include: • Monitoring of remediation methods (e.g. quantity of grout injection). • Hydraulic conductivity testing. • Water quality monitoring (refer above). • Pool water level monitoring (refer above). • Other environmental monitoring (e.g. aquatic ecosystem monitoring).

7.2 REMEDIATION

Current mitigation and remediation methods for subsidence impacts on streams at the Dendrobium Mine are described within the *Dendrobium Colliery Area 3B Watercourse Impact, Monitoring, Management and Contingency Plan* (Illawarra Coal, 2017).

It is proposed that similar remediation methods would be implemented for the Project where subsidence-related physical damage occurs at named watercourses and key stream features.

Various techniques have been previously adopted to successfully reduce subsidence impacts to streams associated with longwall mining, including by Illawarra Coal and at other operations in the Southern Coalfield. A summary of these methods, their possible application to different situations and their limitations are provided in Table 4.

Table 4 Stream Remediation Techniques

Restoration Technique	Description	Applications and Limitations
Hand grouting	Sealing of cracks exposed on the surface using hand applicators. A variety of sealants can be used including sealants that can be applied under water.	Limited to surface cracks which can be accessed using hand held application equipment.
Shallow pattern grouting	Drilling shallow holes using small hand held drilling equipment and low pressure injection of a grout using a portable pump. Grouts used successfully on the Georges River incorporated a cement mix that can be used with or without additives (e.g. bentonite).	Used to seal shallow fractures in rockbars and pools. Applicable to sensitive areas where access for larger equipment is problematic. Better results can be obtained if the target fractures are dewatered.
Deep pattern or curtain grouting	Drilling deeper holes using traditional air and or reverse circulation drilling rigs. Higher pressure grouting techniques can also be used. Grouts used successfully on the Georges River (by Illawarra Coal) incorporated a cement-bentonite mix.	Used to seal fracture networks at greater depths. Can seal larger and deeper fractures. Larger equipment may necessitate constructing access tracks. Less suitable for remote or difficult access sites.
Deep angle hole cement grouting	Remote directional drilling techniques can be used to access otherwise inaccessible sites. The same grouting methods as deep pattern/curtain grouting outlined above can be used.	Specialised technique which can be used in situations where drill access is available close to a target site.
Polyurethane (PUR) grouting	Use of expanding PUR grouts to seal fracture networks. PUR, which is a rapid setting grout that sets under water, is pumped into closely spaced drill holes (pattern drilling) and fractures filled systematically from “bottom up”.	Technique used successfully on Waratah Rivulet by Helensburgh Coal Pty Ltd. Can be used under water and under low flow conditions. Can be used to fill large aperture fractures in stages.
Knick point control	Use of ‘coir log dams’ at erosion knick points to remediate erosion channels and redirect flow to swamps.	Successfully used for swamp rehabilitation in the Blue Mountains and Snowy Mountains. Material eventually biodegrades to become integrated into the peat/organic matter complex of the swamps.
Water spreading techniques	Long lengths of coir logs and hessian ‘sausages’ linked together across the contour to enable build-up of water and facilitate seepage to swamps through water spreaders.	Used to maintain swamp moisture regime. Material eventually biodegrades to become integrated into the peat/organic matter complex of the swamps.

7.3 ACCEPTABILITY OF ENVIRONMENTAL CONSEQUENCES

Through the risk assessment process outlined in this report the most significant streams and stream features that may potentially be affected by subsidence-related impacts from the Project have been identified. These relatively more significant streams and stream features are in addition to water supply infrastructure, namely the Avon and Cordeaux Dam walls and the Avon and Cordeaux Dam full supply levels.

The most significant streams in the Study Area are the Cordeaux and Avon Rivers, on the basis of order permanence of flow, importance to catchment yield, KFH and their function as regulated watercourses for drinking water supply. The next most significant stream is Donalds Castle Creek in terms of order, importance to catchment yield and KFH, however, Donalds Castle Creek is considered to be ephemeral and is not a regulated watercourse.

Accordingly, the Project would setback longwalls from these named watercourses such that 200 mm of additional predicted closure or less would be achieved. The Subsidence Assessment (Appendix A of the EIS) predicts that this would result in a low likelihood (less than 10%) of subsidence-related impacts resulting in the diversion of flow in the short sections of these named watercourses within 400 m of the Project longwalls, and negligible chance of impact for the majority of the lengths of these watercourses which are beyond 400 m from the Project longwalls.

The remaining unnamed streams are lower order (typically second order or less, with short sections of third order streams at the edge of Area 5). These streams are ephemeral, have lower importance to catchment yield and are not regulated watercourses. While third order sections of these streams are considered to potentially contain Type 2 ('Moderately sensitive') KFH, streams of this type are common throughout the catchment area (Appendix E of the EIS).

Within these unnamed, ephemeral streams, it was identified by South32 through site inspection that particular stream features, i.e. pools and steps, were more 'significant' than other stream features. As such, stream features meeting the following definitions have been classified by South32 as 'key stream features':

- Pools with > 100 m^3 and holding water.
- Steps with > 5 m height with a permanent pool at the base.

Accordingly, the Project would setback longwalls from these key stream features of 50 m (where longwall mining occurs on one side) and 100 m (where mining occurs on two or more sides) to reduce the likelihood of subsidence-related impacts to these key stream features.

In summary, the effect of these Project commitments in regard to mining setbacks and remediations is as follows:

- There would be no direct undermining of perennial watercourses or watercourses of fourth order or above, with setbacks to achieve 200 mm additional predicted closure or less.
- South32 does not consider it to be economically feasible to avoid the direct undermining of all ephemeral drainage lines, however, direct undermining of key stream features would be avoided, with setbacks to reduce the likelihood of damage to these features.
- Where physical damage is observed in sections of streams for which setbacks have been proposed, this damage would be remediated.

Residual impacts to stream attributes have been assessed in other EIS appendices, including the Subsidence (Appendix A), Groundwater (Appendix B, HydroSimulations 2018), Surface Water (Appendix C), Biodiversity (Appendix D), Aquatic Ecology (Appendix E) and Aboriginal Cultural Heritage (Appendix F) Assessments.

In summary, potential residual impacts of the proposed longwall layout to streams, and associated impact minimisation and compensatory measures, are as follows:

- Sections of streams that are directly undermined could experience the full range of subsidence impacts, including cracking, associated diversion of flows (when they are present in ephemeral streams) and localised pulses of iron/manganese that may potentially affect water quality.
- There would likely be a reduction in flow duration in the ephemeral streams overlying the longwalls as a result of surface flow diversion to groundwater and/or downstream, however, the reduction in total catchment yield would be negligible (less than 1% at Avon Dam and Pheasants Nest Weir, noting that the Project is not within the catchment of the Cordeaux Dam). South32 would pay WaterNSW for surface water losses resulting from the Project and appropriate water licences would be held for the volume of mine inflows to the Project.
- Any localised water quality impacts are predicted to be insignificant at the catchment scale, based on observations to date. The Project involves the implementation of water quality improvement works in the catchment, and as a result the Project is likely to have a neutral or beneficial effect on water quality in Sydney's water supply catchments (Appendix C of the EIS).
- Potential impacts to upland swamps have been described and assessed in the Surface Water (Appendix C of the EIS) and Biodiversity (Appendix D of the EIS) Assessments in accordance with the requirements of the Addendum to NSW Biodiversity Offsets Policy for Major Projects: Upland swamps impacted by longwall mining subsidence (OEH, 2016).
- Sections of the ephemeral drainage lines overlying the longwall area predicted to experience the full range of subsidence impacts are considered likely to provide habitat for threatened fauna species. However, the Biodiversity Assessment (Appendix D of the EIS) has conservatively assumed that all streams would be potentially affected, irrespective of the setbacks for key stream features, and biodiversity offsets for the Project have been calculated on that conservative assumption to maintain or improve biodiversity.

Table 5 provides a summary of the assessed residual consequences delineated by the level of significance (as described in Section 5.0) of a stream or stream feature.

Table 5 Subsidence Consequence Assessment

Significance	Subsidence Consequence Assessment
Named Streams (Avon River, Cordeaux River and Donalds Castle Creek)	• Likelihood of subsidence impacts reduced to less than 10% for the short sections of these watercourses within 400 m of the longwalls (Appendix A of the EIS). - Avon River – approximately 7% of stream features within the 400 m section of the River within 400 m of longwalls are predicted to be affected - Cordeaux River – approximately 5% of stream features within the 250 m section of the River within 400 m of longwalls are predicted to be affected - Donalds Castle Creek – approximately 9% of stream features within the 2.9 km section of the Creek within 400 m of longwalls are predicted to be affected • Negligible likelihood of impact for the majority of the lengths of these watercourses beyond 400 m from the longwalls (MSEC, 2019).
Key Stream Features	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of the EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of the EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of the EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
Additional Stream Features (not key features) – Not Undermined	• Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).

8.0 REFERENCES

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ATTACHMENT 1 STREAM MAPPING

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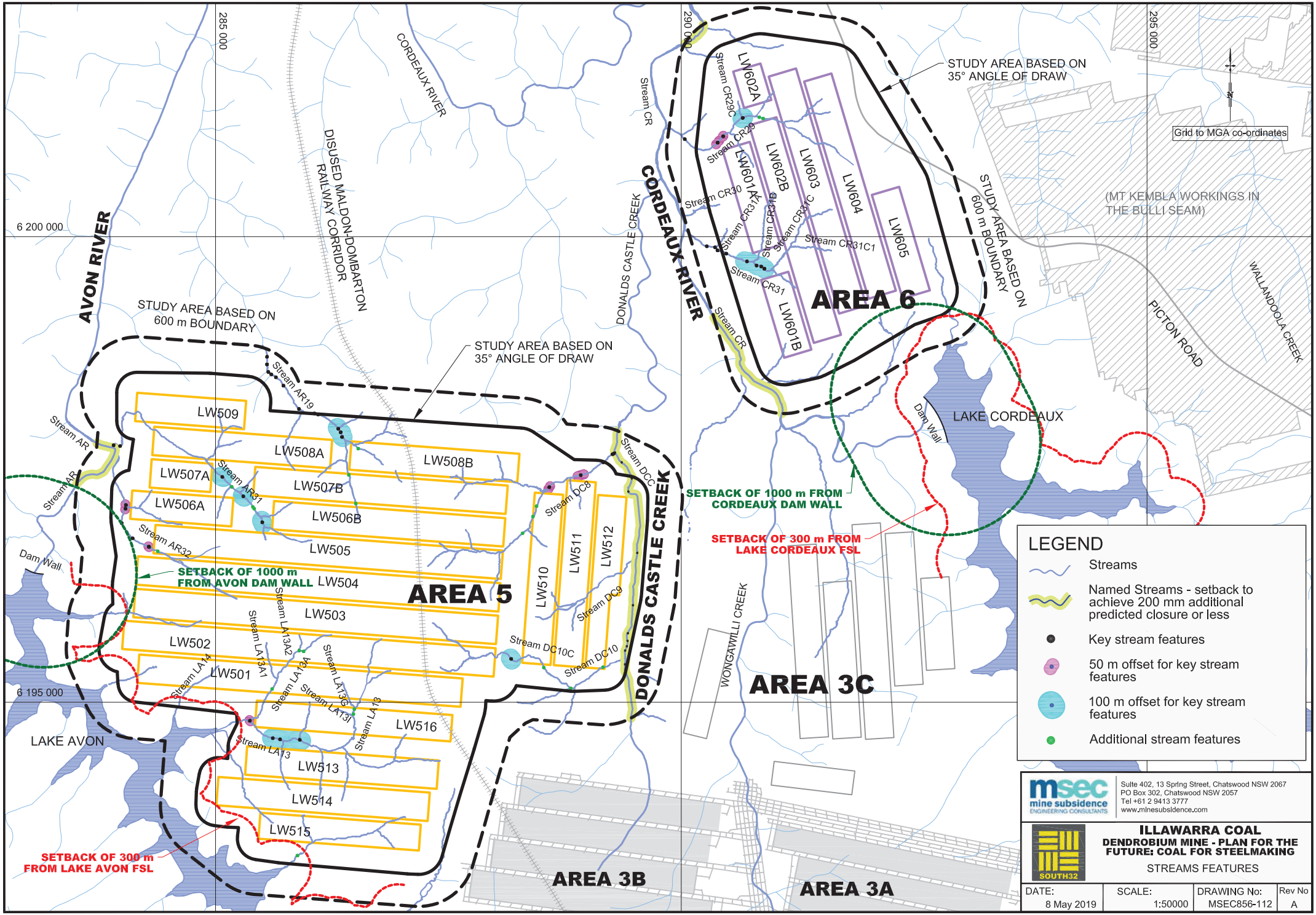

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SOUTH32

ILLAWARRA COAL

DENDROBIUM MINE - PLAN FOR THE FUTURE: COAL FOR STEELMAKING

STREAMS FEATURES

DATE:	SCALE:	DRAWING No:	Rev No
8 May 2019	1:50000	MSEC856-112	A

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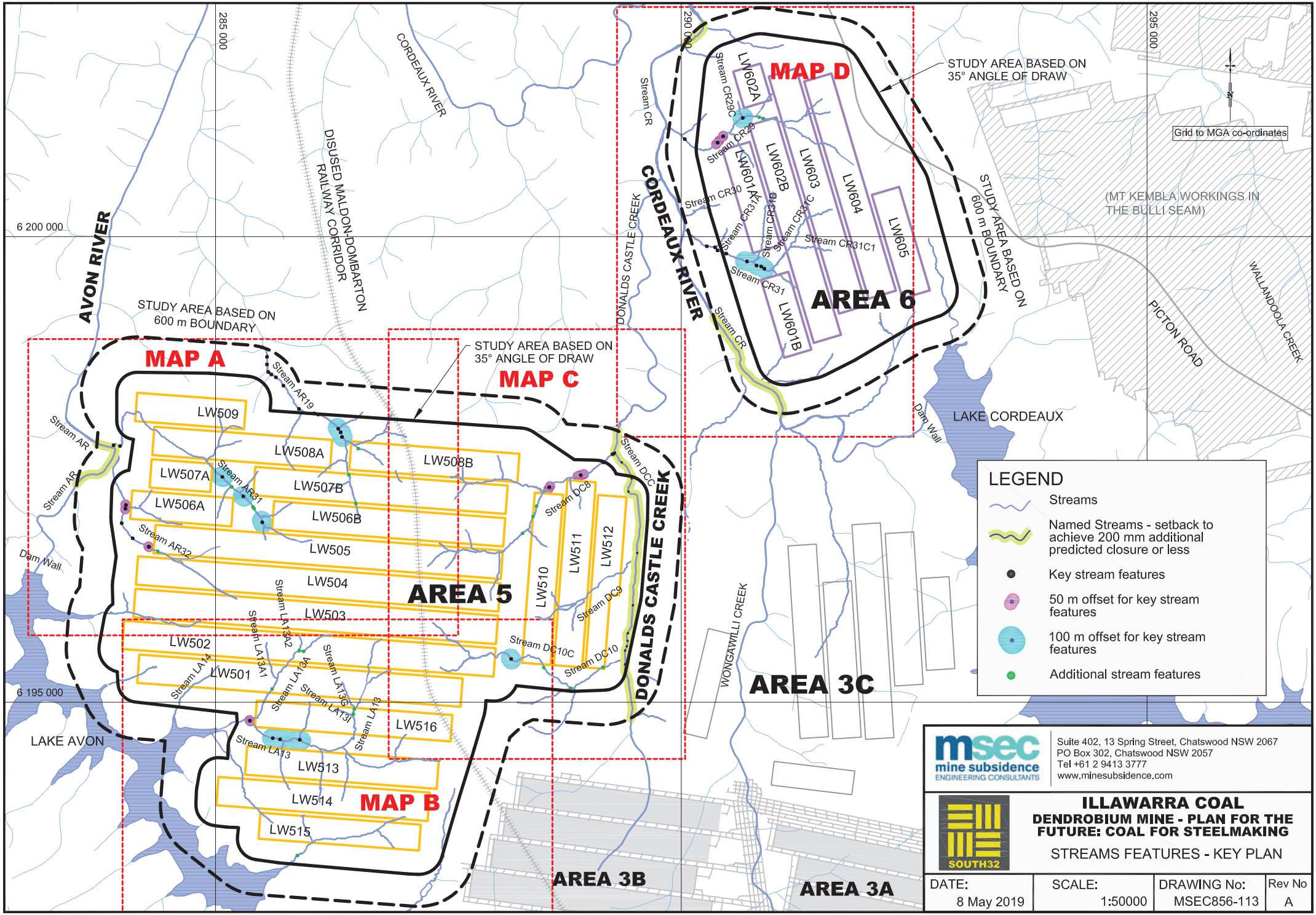

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ILLAWARRA COAL

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STREAMS FEATURES - KEY PLAN

DATE:	SCALE:	DRAWING No:	Rev No
8 May 2019	1:50000	MSEC856-113	A

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ILLAWARRA COAL
DENDROBIUM MINE - PLAN FOR THE FUTURE: COAL FOR STEELMAKING
STREAM KEY FEATURES - MAP A

		Rev No
DATE:	8 May 2019	A
DWG No:	MSEC856-114	

Map A

0m 250m 500m
SCALE

Extent of Map

Extent of Map

STUDY AREA BASED ON 35° ANGLE OF DRAW

STUDY AREA BASED ON 600 m BOUNDARY

LW509 LW508A LW508B LW507A LW507B LW506A LW506B LW505 LW504 LW503

Joins Map B

Joins Map C

Dam Wall

AR31-A AR31-B AR31A-A AR31-C AR32-A AR32A-B AR32A-A AR32-B AR19-A AR19S-A AR19S1-B AR19S1-A AR19S-B AR19-B AR DC8-D LA17-A DC

Stream AR Stream AR31 Stream AR31B Stream AR31C Stream AR31D Stream AR31E Stream AR32 Stream AR32A Stream AR32A1 Stream AR19 Stream AR19R Stream AR19Q Stream AR19S1 Stream AR19S Stream AR19T Stream AR19U Stream DC8B Stream DC8G Stream DC8F Stream LA17

AR31-P1 AR31-Waterfall 1 AR31-P45 AR31-P48 AR31-P52 AR31-ST17 AR31-P55 AR31-P63 AR32-P17 AR32-ST 5 AR32-P22 AR32-ST 8 AR32-P31 AR32-ST 11 AR32-P35 AR19-P4 AR19-P6 AR19-P7 AR19-P8 AR19-P9 AR19-P13 AR19-P21 AR19-P25 AR19-P26 AR19-P31 AR19-P32 AR19-P33 AR19S-ST2 AR19-P41 AR19-P49

LEGEND

- Streams
- Named Streams - setback to achieve 200 mm additional predicted closure or less
- AR — Second & third order stream segments
- Key stream features
- 50 m offset for key stream features
- 100 m offset for key stream features
- Additional stream features

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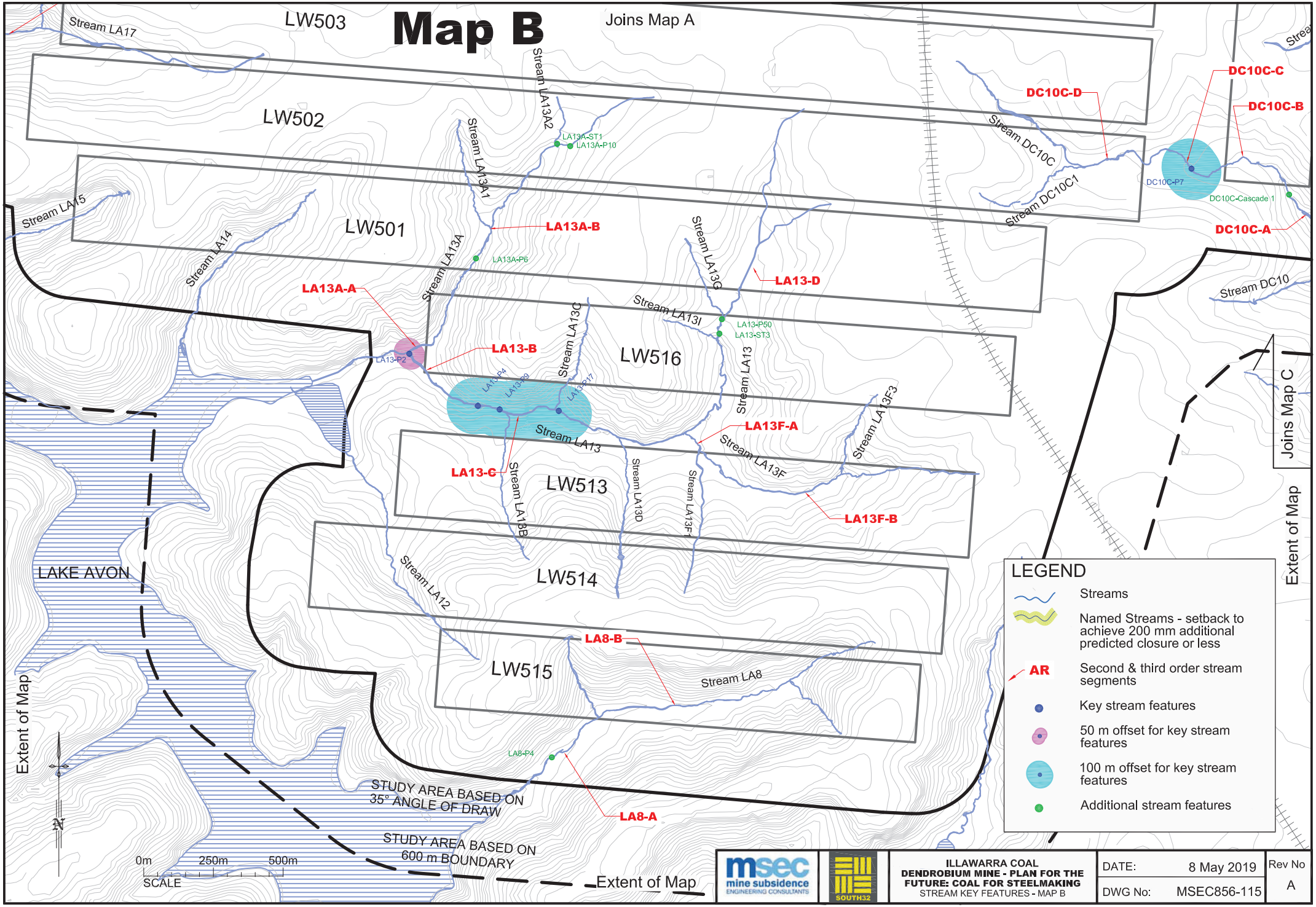

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ILLAWARRA COAL
DENDROBIUM MINE - PLAN FOR THE FUTURE: COAL FOR STEELMAKING
STREAM KEY FEATURES - MAP C

DATE:	8 May 2019	Rev No
DWG No:	MSEC856-116	A

Map C

LEGEND

- Streams
- Named Streams - setback to achieve 200 mm additional predicted closure or less
- AR — Second & third order stream segments
- Key stream features
- 50 m offset for key stream features
- 100 m offset for key stream features
- Additional stream features

Extent of Map

STUDY AREA BASED ON 600 m BOUNDARY

STUDY AREA BASED ON 35° ANGLE OF DRAW

Joins Map D

Joins Map A

Joins Map B

Extent of Map

Extent of Map

LW508B
LW507B
LW506B
LW505
LW504
LW512
LW511
LW510

19S1-A
R19S

DC8-A
DC8B-A
DC8B-B
DC8-B
DC8-C
DC8-D
DC9-A
DC9-B
DC10C-C
DC10C-D
DC10C-B
DC10-A
DC10-B
DC10C-A
DC10-C
DCC

DC8-ST1
DC8-RB1
DC8-ST2
DC8-P9
DC8-P16
DC8-RB18
DC8-CH8
DC8-P20
DCC-P12
DCC-P13
DCC-P18
DCC-P24
DCC-P26
DCC-P36
DCC-P40
DCC-P41
DCC-P42
DCC-P43
DCC-P50
DC10-P5
DC10C-P7
DC10C-Cascade 1
DC10-CH10

Stream DC8
Stream DC8A
Stream DC8B
Stream DC8B1
Stream DC8B2A
Stream DC8C
Stream DC8D
Stream DC8E
Stream DC8F
Stream DC8G
Stream DC9
Stream DC9A
Stream DC9B
Stream DCC
Stream DC10
Stream DC10B
Stream DC10C
Stream DC10C1
Stream LA13F3

0m 250m 500m
SCALE

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msec mine subsidence ENGINEERING CONSULTANTS | SOUTH32

ILLAWARRA COAL
DENDROBIUM MINE - PLAN FOR THE FUTURE: COAL FOR STEELMAKING
STREAM KEY FEATURES - MAP D

		Rev No
DATE:	8 May 2019	A
DWG No:	MSEC856-117	

Map D
Area 6

Extent of Map

Extent of Map

Joins Map C

Extent of Map

Extent of Map

Stream CR25
Stream CR26
Stream CR
Stream CR30
Stream CR31
Stream CR31A
Stream CR31B
Stream CR31C
Stream CR31C1
Stream CR29
Stream CR29A
Stream CR29B
Stream CR29C
Stream CR29D
Stream CR29E
Stream CR29E1
Stream CR33
Stream CR34
Stream CR35
Stream CR37
Stream CR37A

LW602A
LW601A
LW602B
LW603
LW604
LW605
LW601B

CR29-A
CR29-B
CR31-A
CR31C-A
CR31C-B

CR29-P4
CR29-P9
CR29-P33
CR29-P37
CR29-P40
CR29-CH48
CR31-P6
CR31-P10
CR31-P13
CR31-P18
CR31-P26
CR31-P30
CR31-P32
CR31-P33

PICTON RD

STUDY AREA BASED ON 600 m BOUNDARY

STUDY AREA BASED ON 35° ANGLE OF DRAW

LEGEND

- Streams
- Named Streams - setback to achieve 200 mm additional predicted closure or less
- AR — Second & third order stream segments
- Key stream features
- 50 m offset for key stream features
- 100 m offset for key stream features
- Additional stream features

0m 250m 500m
SCALE

River or Significant Stream	River or Significant Stream Section	Undermined (YES/NO)	Mapped Stream Features*	Feature Type	Key Stream Feature (YES/NO)	Feature Characteristics	Subsidence Impact Summary
Avon River							
Avon River Tributary 19S	*Avon River Tributary 19S – Section B*	YES	AR19S_ST2	STEP	NO	The feature holds the following physical characteristics: • Length: 2.5 m • Width: 3.5 m • Height:6.3 m^	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.
Avon River Tributary 19	*Avon River Tributary 19 – Section A*	NO	AR19_P1	POOL	YES	The feature holds the following physical characteristics: • Length: 50 m • Width: 6 m • Depth: 1 m • Volume: 300 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
			AR19_P4	POOL	YES	The feature holds the following physical characteristics: • Length: 47 m • Width: 7.7 m • Depth: 0.7 m • Volume: 253 m^3	
			AR19_P6	POOL	YES	The feature holds the following physical characteristics: • Length: 20 m • Width: 6.4 m • Depth: 1.72 m • Volume: 220 m^3	
			AR19_P7	POOL	YES	The feature holds the following physical characteristics: • Length: 33 m • Width: 6 m • Depth: 1 m • Volume: 198 m^3	
			AR19_P8	POOL	YES	The feature holds the following physical characteristics: • Length: 34 m • Width: 5 m • Depth: 0.7 m • Volume: 119 m^3	
			AR19_P9	POOL	YES	The feature holds the following physical characteristics: • Length: 31 m • Width: 7 m • Depth: 0.8 m • Volume: 174 m^3	
			AR19_P13	POOL	YES	The feature holds the following physical characteristics: • Length: 20 m • Width: 5.2 m • Height: 1.02 m • Volume: 106 m^3	
			AR19_P21	POOL	YES	The feature holds the following physical characteristics: • Length: 20 m • Width: 12 m • Depth: 2 m • Volume: 480 m^3	
			AR19_P25	POOL	YES	The feature holds the following physical characteristics: • Length: 14 m • Width: 7 m • Depth: 1.2 m • Volume: 118 m^3	

River or Significant Stream	River or Significant Stream Section	Undermined (YES/NO)	Mapped Stream Features*	Feature Type	Key Stream Feature (YES/NO)	Feature Characteristics	Subsidence Impact Summary
			AR19_P26	POOL	YES	The feature holds the following physical characteristics: • Length: 31 m • Width: 5 m • Depth: 1 m • Volume: 155 m^3	
			AR19_P31	POOL	YES	The feature holds the following physical characteristics: • Length: 30.5 m • Width: 6 m • Depth: 0.8 m • Volume :146 m^3	
			AR19_P32	POOL	YES	The feature holds the following physical characteristics: • Length: 25 m • Width: 5 m • Depth: 0.9 m • Volume: 112 m^3	
			AR19_P33	POOL	YES	The feature holds the following physical characteristics: • Length: 14 m • Width: 25 m • Depth: 2 m • Volume: 700 m^3	
	Avon River Tributary 19 – Section B	YES	AR19_P41	POOL	NO	The feature holds the following physical characteristics: • Length: 22 m • Width: 4 m • Depth: 0.7 m • Volume: 61.6 m^3	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.
			AR19_P49	POOL	NO	The feature holds the following physical characteristics: • Length: 6 m • Width: 3 m • Depth: 0.8 m • Volume: 14.4 m^3	
Avon River Tributary 31	*Avon River Tributary 31 – Section A*	NO	AR31_P1	POOL	YES	The feature holds the following physical characteristics: • Length: 50 m • Width: 15 m • Depth: 3 m • Volume: 2250 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
			AR31_W1	STEP	YES	The feature holds the following physical characteristics: • Length: 3 m • Width: 4 m • Height: 15 m^	
	Avon River Tributary 31 – Section C	NO	AR31_P48	POOL	NO	The feature holds the following physical characteristics: • Length: 15 m • Width: 4 m • Depth: 0.6 m • Volume: 36 m^3	Not Undermined
			AR31_P45	POOL	YES	The feature holds the following physical characteristics: • Length: 25 m • Width: 7 m • Depth: 1.5 m • Volume: 262 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
			AR31_P52	POOL	YES	The feature holds the following	

River or Significant Stream	River or Significant Stream Section	Undermined (YES/NO)	Mapped Stream Features*	Feature Type	Key Stream Feature (YES/NO)	Feature Characteristics	Subsidence Impact Summary
						physical characteristics: • Length: 18 m • Width: 10 m • Depth: 1 m • Volume: 180 m^3	
			AR31_P55 (AR31_ST17)	POOL/ STEP	NO	The feature holds the following physical characteristics: • Length: 12 m • Width: 3 m • Depth: 0.4 m • Volume: 14.4 m^3	Not Undermined
			AR31_P63	POOL	YES	The feature holds the following physical characteristics: • Length: 30 m • Width: 4.5 m • Depth: 1 m • Volume: 135 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
Avon River Tributary 32	*Avon River Tributary 32 – Section A*	NO	AR32_P17	POOL	YES	The feature holds the following physical characteristics: • Length: 15 m • Width: 11 m • Depth: 1.5 m • Volume: 248 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
			AR32_P22	POOL	YES	The feature holds the following physical characteristics: • Length: 23 m • Width: 5.5 m • Depth: 1.2 m • Volume: 152 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
			AR32_P31 (AR32_ST11)	POOL/ STEP	YES	The feature holds the following physical characteristics: • Length: 8 m • Width: 11 m • Depth: 0.6 m • Volume: 52.8 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
			AR32_ST5	STEP	YES	The feature holds the following physical characteristics: • Length: 12 m • Width: 5 m • Height: 5.5 m^3	
			AR32_ST8	STEP	YES	The feature holds the following physical characteristics: • Length: 10 m • Width: 10 m • Height: 8 m	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
	Avon River Tributary 32 – Section B	YES	AR32_P35	POOL	NO	The feature holds the following physical characteristics: • Length: 6 m • Width: 3 m • Depth: 0.85 m • Volume: 15.3 m^3	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.
Donalds Castle Creek							
Donalds Castle Creek Tributary 8	*Donalds Castle Creek Tributary 8 – Section A*	NO	DC8_RB1 (DC8_ST1)	STEP	YES	The feature holds the following physical characteristics: • Length: 15 m • Width: 5 m • Height: 5 m	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
			DC8_ST2	STEP	YES	The feature holds the following physical characteristics:	

River or Significant Stream	River or Significant Stream Section	Undermined (YES/NO)	Mapped Stream Features*	Feature Type	Key Stream Feature (YES/NO)	Feature Characteristics	Subsidence Impact Summary
						• Length: - • Width: - • Height: 5 m^3	
			DC8_P9	POOL	YES	The feature holds the following physical characteristics: • Length: 68 m • Width: 5.5 m • Depth: 0.69 m • Volume: 258 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
			DC8_P16	POOL	YES	The feature holds the following physical characteristics: • Length: 34 m • Width: 4.5 m • Depth: 1.1 m • Volume: 168 m^3	
	Donalds Castle Creek Tributary 8 – Section B	YES	DC8_RB18 (DC8_Channel8)	ROCKBAR	NO	The feature holds the following physical characteristics: • Length: 35 m • Width: 2.1 m • Height: 0.5 m • Volume: 36.75 m^3	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.
	Donalds Castle Creek Tributary 8 – Section C	NO	DC8_P20	POOL	NO	The feature holds the following physical characteristics: • Length: 6 m • Width: 4 m • Depth: 0.8 m • Volume: 19.2 m^3	Not Undermined
			DC8_Channel8	CHANNEL	NO	The feature holds the following physical characteristics: • Length: 35 m • Width: 2.1 m • Height: 0.5 m • Volume: 36.75 m^3	
Donalds Castle Creek Tributary 10	*Donalds Castle Creek Tributary 10 – Section B*	YES	DC10_P5	POOL	NO	The feature holds the following physical characteristics: • Length: 14 m • Width: 7 m • Depth: 0.8 m • Volume: 77 m^3	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.
	Donalds Castle Creek Tributary 10 – Section C	NO	DC10_Channel10	CHANNEL	NO	The feature holds the following physical characteristics: • Length: 17 m • Width: 2 m • Height: 0.5 m • Volume: 24 m^3	Not Undermined
Donalds Castle Creek Tributary 10C	*Donalds Castle Creek Tributary 10C – Section A*	NO	DC10C_Cascade1	CASCADE	NO	The feature holds the following physical characteristics: • Length: 11 m • Width: 2.5 m • Height: 3 m^3	
	Donalds Castle Creek Tributary 10C – Section C	NO	DC10C_P7	POOL	YES	The feature holds the following physical characteristics: • Length: 21 m • Width: 11.5 m • Depth: 1 m • Volume: 164 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
Donalds Castle Creek	**Donalds Castle Creek**	NO	DCC_P7	POOL	YES	The feature holds the following physical characteristics: • Length: 65 m • Width: 35 m	Not undermined - Named stream setback incorporated to achieve no greater than 200 mm of additional predicted closure.

River or Significant Stream	River or Significant Stream Section	Undermined (YES/NO)	Mapped Stream Features*	Feature Type	Key Stream Feature (YES/NO)	Feature Characteristics	Subsidence Impact Summary
						• Depth: 2.5 m • Volume: 5688 m^3	
			DCC_P12	POOL	YES	The feature holds the following physical characteristics: • Length: 30 m • Width: 20 m • Depth: 1.5 m • Volume: 900 m^3	
			DCC_P13	POOL	YES	The feature holds the following physical characteristics: • Length: 25 m • Width: 12 m • Depth: 0.6 m • Volume: 180 m^3	
			DCC_P18	POOL	YES	The feature holds the following physical characteristics: • Length: 94.4 m • Width: 8.2 m • Depth: 1.5 m • Volume: 1161 m^3	
			DCC_P24	POOL	YES	The feature holds the following physical characteristics: • Length: 17.1 m • Width: 8.4 m • Depth: 1.6 m • Volume: 230 m^3	
			DCC_P26	POOL	YES	The feature holds the following physical characteristics: • Length: 30 m • Width: 15 m • Depth: 1.5 m • Volume: 675 m^3	
			DCC_P36	POOL	YES	The feature holds the following physical characteristics: • Length: 65 m • Width: 7 m • Depth: 0.7 m • Volume: 318 m^3	
			DCC_P40	POOL	YES	The feature holds the following physical characteristics: • Length: 127 m • Width: 5.8 m • Depth: 2.5 m • Volume:1842 m^3	
			DCC_P41	POOL	YES	The feature holds the following physical characteristics: • Length: 30 m • Width: 3.6 m • Depth: 1.8 m • Volume: 194 m^3	
			DCC_P42	POOL	YES	The feature holds the following physical characteristics: • Length: 45 m • Width: 3.4 m • Depth: 1.2 m • Volume: 184 m^3	
			DCC_P43	POOL	YES	The feature holds the following physical characteristics: • Length: 32 m • Width: 6.7 m	

River or Significant Stream	River or Significant Stream Section	Undermined (YES/NO)	Mapped Stream Features*	Feature Type	Key Stream Feature (YES/NO)	Feature Characteristics	Subsidence Impact Summary
						• Depth: 2 m • Volume: 429 m^3	
			DCC_P50	POOL	YES	The feature holds the following physical characteristics: • Length: 32 m • Width: 15 m • Depth: 3 m • Volume: 1440 m^3	
Lake Avon							
Lake Avon Tributary 8	*Lake Avon Tributary 8 – Section A*	NO	LA8_P4	POOL	NO	The feature holds the following physical characteristics: • Length: 35 m • Width: 2.8 m • Depth: 1.2 m • Volume: 117 m^{3}^	Not undermined - Named stream setback incorporated to achieve no greater than 200 mm of additional predicted closure.
Lake Avon Tributary 13A	*Lake Avon Tributary 13A – Section B*	YES	LA13A_P6	POOL	NO	The feature holds the following physical characteristics: • Length: 10 m • Width: 5 m • Depth: 1.5 m • Volume: 75 m^3	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.
			LA13A_ST1	STEP	NO	The feature holds the following physical characteristics: • Length: - • Width: - • Height: 1.6 m^3	
			LA13A_P10	POOL	NO	The feature holds the following physical characteristics: • Length: 3 m • Width: 1.5 m • Depth: 0.2 m • Volume: 1 m^3	
Lake Avon Tributary 13	*Lake Avon Tributary 13 – Section A*	NO	LA13_P2	POOL	YES	The feature holds the following physical characteristics: • Length: 16 m • Width: 13.5 m • Depth: 0.5 m • Volume: 108 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
	Lake Avon Tributary 13 – Section C	NO	LA13_P4	POOL	YES	The feature holds the following physical characteristics: • Length: 30 m • Width: 20 m • Depth: 2 m • Volume: 1200 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides..
			LA13_P9	POOL	YES	The feature holds the following physical characteristics: • Length: 13 m • Width: 7 m • Depth: 1.5 m • Volume: 136 m^3	
			LA13_P17	POOL	YES	The feature holds the following physical characteristics: • Length: 48 m • Width: 4.5 m • Depth: 1.5 m • Volume: 324 m^3	
	Lake Avon Tributary 13 – Section D	YES	LA13_P50	POOL	NO	The feature holds the following physical characteristics: • Length: 7 m • Width: 2.5 m	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.

River or Significant Stream	River or Significant Stream Section	Undermined (YES/NO)	Mapped Stream Features*	Feature Type	Key Stream Feature (YES/NO)	Feature Characteristics	Subsidence Impact Summary
						• Depth: 0.35 m • Volume: 6.125 m^3	
			LA13_ST3	STEP	NO	The feature holds the following physical characteristics: • Length: - • Width: 4 m • Height: 7 m^3	
Cordeaux River							
Cordeaux River Tributary 29	*Cordeaux River Tributary 29 – Section A*	NO	CR29_P4	POOL	YES	The feature holds the following physical characteristics: • Length: 31 m • Width: 5 m • Depth: 1.1 m • Volume: 170 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
			CR29_P9	POOL	YES	The feature holds the following physical characteristics: • Length: 21 m • Width: 6 m • Depth: 1.2 m • Volume: 151 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
			CR29_P35	POOL	YES	The feature holds the following physical characteristics: • Length: 11.5 m • Width: 11.1 m • Depth: 1 m • Volume: 172 m^3	
			CR29_P37	POOL	YES	The feature holds the following physical characteristics: • Length: 18.7 m • Width: 15.4 m • Depth: 2.5 m6.5 • Volume: 720 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
			CR29_P40	POOL	NO	The feature holds the following physical characteristics: • Length: 6.5 m • Width: 3 m • Depth: 1 m • Volume: 19.5 m^3	Not undermined.
			CR29_Channel48	CHANNEL	NO	The feature holds the following physical characteristics: • Length: 55 m • Width: 2 m • Depth: 0.8 m • Volume: 88 m^3	
Cordeaux River Tributary 31	*Cordeaux River Tributary 31 – Section A*	NO	CR31_P6	POOL	YES	The feature holds the following physical characteristics: • Length: 28 m • Width: 9 m • Depth: 1 m • Volume: 252 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides..
			CR31_P10	POOL	YES	The feature holds the following physical characteristics: • Length: 34 m • Width: 4.5 m • Depth: 0.8 m • Volume: 122 m^3	
			CR31_P13	POOL	YES	The feature holds the following physical characteristics: • Length: 14.3 m • Width: 12 m	

River or Significant Stream	River or Significant Stream Section	Undermined (YES/NO)	Mapped Stream Features*	Feature Type	Key Stream Feature (YES/NO)	Feature Characteristics	Subsidence Impact Summary
						• Depth: 2 m • Volume: 343 m^3	
			CR31_P18	POOL	YES	The feature holds the following physical characteristics: • Length: 23.5 m • Width: 23.3 m • Depth: 3 m • Volume: 1648 m^3	
			CR31_P26	POOL	YES	The feature holds the following physical characteristics: • Length: 55 m • Width: 4.3 m • Depth: 0.9 m • Volume: 202 m^3	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.
			CR31_P30	POOL	YES	The feature holds the following physical characteristics: • Length: 25 m • Width: 8 m • Depth: 0.6 m • Volume: 120 m^3	
			CR31_P32	POOL	YES	The feature holds the following physical characteristics: • Length: 50 m • Width: 6 m • Depth: 0.9 m • Volume: 264 m^3	
			CR31_P33	POOL	YES	The feature holds the following physical characteristics: • Length: 25 m • Width: 10 m • Depth: 0.6 m • Volume: 162 m^3	

Named Stream – setback to achieve 200 mm additional predicted closure or less
50 m offset for selected/ key stream features
100 m offset for selected/key stream feature
Additional stream section or non-key stream feature not undermined by EIS base case mine plan
^approximated or inferred
-information not available or measurable

ATTACHMENT 2 STREAM MATRIX

River or Significant Stream	Topographic Characteristics: Maximum Strahler Stream Order	Approximate Stream Length within Extent of Longwall Mining Area 35° Angle of Draw (km)	Approximate Stream Length within 600m of Extent of Longwall Mining Area (km)	Average Stream Gradient	Geomorphic Type	In-Stream/Visual Amenity Features	Hydrologic Characteristics: Stream Catchment Area (km²)	Permanence of Flow (Perennial vs Intermittent)	Stream Regulation History	Importance to Catchment Yield**: Percentage of Avon River Catchment Area	Percentage of Donalds Castle Creek Catchment Area	Percentage of Lake Avon Catchment Area	Percentage of Cordeaux River Catchment Area	Ecological Significance: Environmental Quality (Observed/ Existing Disturbance)	Flora and Fauna Survey Sites	EECs Present in Riparian Zone	Key Fish Habitat Type	Threatened Species Recorded during Project Surveys and/or Described in Aquatic Ecology Assessment: Records within Streams	Records Adjacent to Stream in Riparian or Gully Habitats	Associated Land Use: Land Zoning	Public Accessibility	Mapping and Photos: Stream Photos	Stream Mapping	Stream Risk Management Zone
Avon River																								
Avon River Tributary 19S1	2	0.54	0.60	70	n/a	Channel	0.44	Intermittent	No	0.25%	n/a	n/a	n/a	P	FLR, FLB	n/a	n/a	n/a	n/a	WC	None	n/a	Refer Map A	Area 5
Avon River Tributary 19S	2	0.83	0.83	62	V2, FP1, B1, DF1	Channel	1.07	Intermittent	No	0.62%	n/a	n/a	n/a	P	FLR, FLB	MU43	n/a	n/a	n/a	WC	None	Refer Plate 1	Refer Map A	Area 5
Avon River Tributary 19	3	1.79	2.81	29	V2, FP1, B1, DF1	Pools	3.93	Intermittent	No	2.26%	n/a	n/a	n/a	P	FLR, FLB, FT	n/a	Type 2	n/a	LJT, RG	WC	None	Refer Plate 2	Refer Map A	Area 5
Avon River Tributary 31A	2	0.60	0.60	143	V2, FP1, B1, DF1	Rockbars	0.32	Intermittent	No	0.19%	n/a	n/a	n/a	P	FT	n/a	n/a	n/a	n/a	WC	None	Refer Plate 3	Refer Map A	Area 5
Avon River Tributary 31	3	2.52	2.77	32	V2, FP1, B1/B3, DF6/DF1	Pools	3.02	Intermittent	No	1.74%	n/a	n/a	n/a	P	FLR, AQ, FT	MU44b	Type 2	n/a	EBB	WC	None	Refer Plate 4	Refer Map A	Area 5
Avon River Tributary 32A	2	0.66	0.66	146	V2, FP1, B1, DF1	Rockbars	0.33	Intermittent	No	0.19%	n/a	n/a	n/a	P	n/a	n/a	n/a	n/a	n/a	WC	None	Refer Plate 5	Refer Map A	Area 5
Avon River Tributary 32	3	2.05	2.40	48	V2, FP1, B1/B3, DF6/DF1	Pools	1.72	Intermittent	No	0.99%	n/a	n/a	n/a	P	FLR, FLB, AQ	MU44b	Type 2	n/a	n/a	WC	None	Refer Plate 6	Refer Map A	Area 5
Avon River	5	0.00	6.82	7	V1, FP1, B1, DF1	Channel	150.35	Perennial	Yes	86.47%	n/a	n/a	n/a	P	n/a	n/a	Type 1	n/a	n/a	WC	None	Refer Plate 7	Refer Map A	Area 5
Donalds Castle Creek																								
Donalds Castle Creek Tributary 8B	2	1.22	1.22	56	V2, FP1, B1/B3, DF4	Channel	0.68	Intermittent	No	n/a	4.88%	n/a	0.10%	P	FLB, FT	n/a	n/a	n/a	RG	WC	None	Refer Plate 8	Refer Map C	Area 5
Donalds Castle Creek Tributary 8	3	2.55	2.69	35	V2, FP1, B1, DF1	Channel	2.55	Intermittent	No	n/a	18.17%	n/a	0.37%	P	FLR, FLB, FT	n/a	Type 2	n/a	LJT	WC	None	Refer Plate 9	Refer Map C	Area 5
Donalds Castle Creek Tributary 9	2	1.28	1.28	63	V2, FP1, B1, DF1	Channel	1.05	Intermittent	No	n/a	7.50%	n/a	0.15%	P	FLR, FLB, FT	MU42, MU43, MU44b	n/a	n/a	n/a	WC	None	Refer Plate 10	Refer Map C	Area 5

Predicted Subsidence Effects: River or Stream Section	Named?	Undermined/ Not Undermined	Minimum Depth of Cover Above Mining Area (m)	Geological Formation	Conventional Subsidence Parameters: Total Maximum Predicted Subsidence (mm)	Total Maximum Predicted Tilt (mm/m)	Stream Long Section - Tilt and Grade	Maximum Equivalent Valley Height (MEVH) (m)	Easting (at MEVH)	Northing (at MEVH)	Non-Conventional Subsidence Parameters: Maximum Predicted Upsidence (mm)	Stream Long Section - Equivalent Valley Height, Upsidence and Closure	Length of Stream with greater than 200 mm Closure (m)	Mapped Stream Features*	Identified as Key Stream Feature?^	Subsidence Impact Summary	Subsidence Impact Assessment
Avon River																	
Avon River Tributary 19S1 – Section A	No	Undermined	335	Hawkesbury Sandstone	100	2	NO	28	286485	6197765	200	YES	50	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Avon River Tributary 19S1 – Section B	No	Not Undermined	335	Hawkesbury Sandstone	70	1	NO	18	286580	6197785	125	YES	0	None	None	Not Undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Avon River Tributary 19S – Section A	No	Not Undermined	330	Hawkesbury Sandstone	50	1	NO	28	286400	6197800	200	NO	70	None	None	Not Undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Avon River Tributary 19S – Section B	No	Undermined	330	Hawkesbury Sandstone	100	2	NO	28	286480	6197760	225	NO	30	AR19S_ST2	NO	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Avon River Tributary 19 – Section A	No	Not Undermined	340	Hawkesbury Sandstone	100	3	YES	36	286385	6197825	475	YES	740	AR19_P1 AR19_P4 AR19_P6 AR19_P7 AR19_P8 AR19_P9 AR19_P13 AR19_P21 AR19_P25 AR19_P26 AR19_P31 AR19_P32 AR19_P33	YES YES YES YES YES YES YES YES YES YES YES YES YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
Avon River Tributary 19 – Section B	No	Undermined	340	Hawkesbury Sandstone	1450	18	YES	31	286420	6197465	475	YES	480	AR19_P41 AR19_P49	NO NO	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Avon River Tributary 31A – Section A	No	Undermined	285	Hawkesbury Sandstone	1850	18	NO	58	285020	6197735	750	YES	200	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Avon River Tributary 31 – Section A	No	Not Undermined	280	Hawkesbury Sandstone	50	1	YES	60	284155	6198090	300	YES	10	AR31_P1 AR31_W1	YES YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
Avon River Tributary 31 – Section B	No	Undermined	280	Hawkesbury Sandstone	1950	20	YES	67	284685	6197685	775	YES	1050	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Avon River Tributary 31 – Section C	No	Not Undermined	285	Hawkesbury Sandstone	775	2	YES	61	284950	6197535	650	YES	880	AR31_P48	NO	Not Undermined	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
														AR31_P45 AR31_P52	YES YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
														AR31_P55 (AR31_ST17)	NO	Not Undermined	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
														AR31_P63	YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
Avon River Tributary 32A – Section A	No	Not Undermined	270	Hawkesbury Sandstone	50	1	NO	41	284090	6197090	325	YES	50	None	None	Not Undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Avon River Tributary 32A – Section B	No	Undermined	270	Hawkesbury Sandstone	350	10	NO	41	284160	6197090	425	YES	90	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Avon River Tributary 32 – Section A	No	Not Undermined	320	Hawkesbury Sandstone	50	1	YES	59	284005	6197205	400	YES	1100	AR32_P17	YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
														AR32_P22	YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
														AR32_P31 (AR32_ST11) AR32_ST5	YES YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
														AR32_ST8	YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
Avon River Tributary 32 – Section B	No	Undermined	320	Hawkesbury Sandstone	825	8	YES	31	284325	6196640	400	YES	290	AR32_P35	NO	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Avon River	Yes	Not Undermined	270	Hawkesbury Sandstone	< 20	< 1	NO	60	283925	619770	90	YES	< 20	Not Mapped***	n/a	Not undermined - Named stream setback incorporated to achieve no greater than 200 mm of additional predicted closure.	• Likelihood of subsidence impacts reduced to less than 10% for the short sections of these watercourses within 400 m of the longwalls (MSEC, 2019). o Avon River – 7% likelihood for 400 m section of river within 400 m of longwalls • Negligible likelihood of impact for the majority of the lengths of these watercourses beyond 400 m from the longwalls (MSEC, 2019).
Donalds Castle Creek																	
Donalds Castle Creek Tributary 8B – Section A	No	Not Undermined	320	Hawkesbury Sandstone	40	1	NO	50	288210	6197365	500	YES	350	None	None	Not Undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Donalds Castle Creek Tributary 8B – Section B	No	Undermined	320	Hawkesbury Sandstone	550	6	NO	50	288145	6197390	375	YES	530	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Donalds Castle Creek Tributary 8 – Section A	No	Not Undermined	315	Hawkesbury Sandstone	40	1	YES	45	288945	6197445	500	YES	720	DC8_RB1 (DC8_ST1) DC8_ST2	YES YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
														DC8_P9 DC8_P16	YES YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
Donalds Castle Creek Tributary 8 – Section B	No	Undermined	315	Hawkesbury Sandstone	450	4	YES	44	288525	6197255	475	YES	280	DC8_RB18 (DC8_Channel8)	NO	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Donalds Castle Creek Tributary 8 – Section C	No	Not Undermined	315	Hawkesbury Sandstone	400	2	YES	43	288420	6197005	450	YES	530	DC8_P20 DC8_Channel8	NO NO	Not undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Donalds Castle Creek Tributary 8 – Section D	No	Undermined	335	Hawkesbury Sandstone	800	7	YES	38	288090	6196620	400	YES	610	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Donalds Castle Creek Tributary 9 – Section A	No	Not Undermined	320	Hawkesbury Sandstone	150	5	YES	31	289350	6196385	175	YES	260	None	None	Not undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).

River or Significant Stream	Topographic Characteristics						Hydrologic Characteristics							Ecological Significance						Associated Land Use		Mapping and Photos		
	Maximum Strahler Stream Order	Approximate Stream Length within Extent of Longwall Mining Area 35° Angle of Draw (km)	Approximate Stream Length within 600m of Extent of Longwall Mining Area (km)	Average Stream Gradient	Geomorphic Type	In-Stream/Visual Amenity Features	Stream Catchment Area (km^2)	Permanence of Flow (Perennial vs Intermittent)	Stream Regulation History	Importance to Catchment Yield**				Environmental Quality (Observed/ Existing Disturbance)	Flora and Fauna Survey Sites	EECs Present in Riparian Zone	Key Fish Habitat Type	Threatened Species Recorded during Project Surveys and/or Described in Aquatic Ecology Assessment		Land Zoning	Public Accessibility	Stream Photos	Stream Mapping	Stream Risk Management Zone
										Percentage of Avon River Catchment Area	Percentage of Donalds Castle Creek Catchment Area	Percentage of Lake Avon Catchment Area	Percentage of Cordeaux River Catchment Area					Records within Streams	Records Adjacent to Stream in Riparian or Gully Habitats					
Donalds Castle Creek Tributary 10	2	0.79	1.34	79	V1/V2, FP1, B1/B3, DF1	Channel	2.86	Intermittent	No	n/a	20.39%	n/a	0.42%	P	FLR, FLB, FT	MU44b	n/a	n/a	GBB	WC	None	Refer Plate 10	Refer Map C	Area 5
Donalds Castle Creek Tributary 10C	2	2.00	2.00	28	V2, FP1, B1/B3, DF4	Channel	1.63	Intermittent	No	n/a	11.65%	n/a	0.24%	P	FLR, FT	n/a	n/a	n/a	n/a	WC	None	Refer Plate 12	Refer Map C	Area 5
Donalds Castle Creek	4	2.24	3.32	14	V2, FP1, B1, DF1	Pools	11.39	Intermittent	No	n/a	81.21%	n/a	1.67%	P	FLR, FLB, AQ, DCC	MU44b, MU44c	Type 1	n/a	n/a	WC	None	Refer Plate 11	Refer Map C	Area 5
Lake Avon																								
Lake Avon Tributary 6	2	0.63	1.28	43	V2, FP1, B1/B3, DF5	Channel	0.95	Intermittent	No	0.55%	n/a	0.67%	n/a	P	n/a	MU44b	n/a	n/a	n/a	WC	None	Refer Plate 12.	Refer Map B	Area 5
Lake Avon Tributary 8	2	1.45	2.14	40	V2, FP1, B1/B3, DF5	Channel	1.26	Intermittent	No	0.72%	n/a	0.88%	n/a	P	FLB	n/a	n/a	n/a	n/a	WC	None	Refer Plate 13	Refer Map B	Area 5
Lake Avon Tributary 13A	2	1.44	1.44	52	V1/V2, FP1, B1/B3, DF1	Channel	1.08	Intermittent	No	0.62%	n/a	0.76%	n/a	P	FT	MU44b, MU43, MU42	n/a	n/a	n/a	WC	None	Refer Plate 14	Refer Map B	Area 5
Lake Avon Tributary 13F	2	1.22	1.22	51	V2, FP1, B1/B3, DF5	Channel	0.95	Intermittent	No	0.55%	n/a	0.67%	n/a	P	n/a	n/a	n/a	n/a	n/a	WC	None	Refer Plate 15	Refer Map B	Area 5
Lake Avon Tributary 13	3	2.72	3.57	22	V2, FP1, B1/B3, DF1	Channel	5.56	Intermittent	No	3.20%	n/a	3.89%	n/a	P	n/a	n/a	Type 2	n/a	n/a	WC	None	Refer Plate 16	Refer Map B	Area 5
Lake Avon Tributary 17	2	1.11	1.52	42	V1/V2, FP1, B1/B3, DF3	Channel	1.00	Intermittent	No	0.58%	n/a	0.70%	n/a	P	n/a	n/a	n/a	n/a	n/a	WC	None	Refer Plate 17	Refer Map B	Area 5
Cordeaux River																								
Cordeaux River Tributary 29	2	1.93	2.28	38	V2, FP1, B1, DF1	Channel	2.25	Intermittent	No	n/a	n/a	n/a	0.33%	P	FLR, FLB, FT	MU43	n/a	GD	RG	WC	None	Refer Plate 18	Refer Map D	Area 6
Cordeaux River Tributary 31	2	0.98	1.41	26	V2, FP1, B1, DF1	Channel	2.59	Intermittent	No	n/a	n/a	n/a	0.38%	P	FLR, FLB	n/a	n/a	n/a	LJT	WC	None	Refer Plate 19	Refer Map D	Area 6
Cordeaux River Tributary 31C	2	1.10	1.10	54	V2, FP1, B1, DF1	Channel	1.18	Intermittent	No	n/a	n/a	n/a	0.17%	P	FLR, FLB, FT	MU44b	n/a	n/a	n/a	WC	None	Refer Plate 22	Refer Map D	Area 6
Cordeaux River	5	0.00	5.08	2	V1, FP1, B1, DF1/DF3	Channel	135.47	Perennial	Yes	n/a	n/a	n/a	19.88%	P	FT	n/a	Type 1	n/a	n/a	WC	None	Refer Plate 20	Refer Map D	Area 6

River or Significant Stream	Predicted Subsidence Effects																	
	River or Stream Section	Named?	Undermined/ Not Undermined	Minimum Depth of Cover Above Mining Area (m)	Geological Formation	Conventional Subsidence Parameters – Total Maximum Predicted Subsidence (mm)	Conventional Subsidence Parameters – Total Maximum Predicted Tilt (mm/m)	Stream Long Section - Tilt and Grade	Maximum Equivalent Valley Height (MEVH) (m)	Easting (at MEVH)	Northing (at MEVH)	Non-Conventional Subsidence Parameters – Maximum Predicted Upsidence (mm)	Stream Long Section - Equivalent Valley Height, Upsidence and Closure	Length of Stream with greater than 200 mm Closure (m)	Mapped Stream Features*	Identified as Key Stream Feature?^	Subsidence Impact Summary	Subsidence Impact Assessment
	Donalds Castle Creek Tributary 9 – Section B	No	Undermined	320	Hawkesbury Sandstone	1550	16	YES	31	289070	6196225	525	YES	820	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Donalds Castle Creek Tributary 10	*Donalds Castle Creek Tributary 10 – Section A*	No	Not Undermined	325	Hawkesbury Sandstone	60	1	YES	32	289180	6195375	225	YES	< 10	None	None	Not undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Donalds Castle Creek Tributary 10	*Donalds Castle Creek Tributary 10 – Section B*	No	Undermined	325	Hawkesbury Sandstone	60	1	YES	32	289135	6195365	250	YES	50	DC10_P5	NO	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Donalds Castle Creek Tributary 10	*Donalds Castle Creek Tributary 10 – Section C*	No	Not Undermined	325	Hawkesbury Sandstone	50	1	YES	32	288935	6195220	225	YES	100	DC10_Channel10	NO	Not undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Donalds Castle Creek Tributary 10C	*Donalds Castle Creek Tributary 10C – Section A*	No	Not Undermined	340	Hawkesbury Sandstone	60	1	YES	32	288820	6195145	350	YES	250	DC10C_Cascade1	NO	Not undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Donalds Castle Creek Tributary 10C	*Donalds Castle Creek Tributary 10C – Section B*	No	Undermined	340	Hawkesbury Sandstone	150	3	YES	30	288515	6195400	425	YES	130	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Donalds Castle Creek Tributary 10C	*Donalds Castle Creek Tributary 10C – Section C*	No	Not Undermined	355	Hawkesbury Sandstone	70	1	YES	20	288310	6195480	250	YES	0	DC10C_P7	YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
Donalds Castle Creek Tributary 10C	*Donalds Castle Creek Tributary 10C – Section D*	No	Undermined	360	Hawkesbury Sandstone	1250	13	YES	18	288010	6195480	350	YES	0	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Donalds Castle Creek	*Donalds Castle Creek*	Yes	Not Undermined	325	Hawkesbury Sandstone	< 20	< 1	NO	45	289300	6197750	100	YES	1830	DCC_P7 DCC_P12 DCC_P13 DCC_P18 DCC_P24 DCC_P26 DCC_P36 DCC_P40 DCC_P41 DCC_P42 DCC_P43 DCC_P50	YES YES YES YES YES YES YES YES YES YES YES YES	Not undermined - Named stream setback incorporated to achieve no greater than 200 mm of additional predicted closure.	• Likelihood of subsidence impacts reduced to less than 10% for the short sections of these watercourses within 400 m of the longwalls (MSEC, 2019). ○ Donalds Castle Creek – 9% likelihood for 2.9 km section of river within 400 m of longwalls • Negligible likelihood of impact for the majority of the lengths of these watercourses beyond 400 m from the longwalls (MSEC, 2019).
Lake Avon																		
Lake Avon Tributary 6	Lake Avon Tributary 6	No	Not Undermined	360	Hawkesbury Sandstone	< 20	< 1	NO	49	287435	6193485	150	YES	< 20	None	None	Not undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Lake Avon Tributary 8	*Lake Avon Tributary 8 – Section A*	No	Not Undermined	250	Hawkesbury Sandstone	50	1	NO	40	285765	6193235	200	YES	390	LA8_P4	NO	Not undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Lake Avon Tributary 8	*Lake Avon Tributary 8 – Section B*	No	Undermined	250	Hawkesbury Sandstone	1500	10	NO	52	286730	6193630	600	YES	740	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Lake Avon Tributary 13A	*Lake Avon Tributary 13A – Section A*	No	Not Undermined	270	Hawkesbury Sandstone	50	1	NO	54	285410	6194765	328	YES	20	None	None	Not undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Lake Avon Tributary 13A	*Lake Avon Tributary 13A – Section B*	No	Undermined	270	Hawkesbury Sandstone	1700	17	NO	54	285540	6195045	875	YES	860	LA13A_P6 LA13A_ST1 LA13A_P10	NO NO NO	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Lake Avon Tributary 13F	*Lake Avon Tributary 13F – Section A*	No	Not Undermined	295	Hawkesbury Sandstone	100	4	NO	33	286350	6194515	150	YES	80	None	None	Not undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Lake Avon Tributary 13F	*Lake Avon Tributary 13F – Section B*	No	Undermined	295	Hawkesbury Sandstone	1500	19	NO	33	286850	6194320	600	YES	590	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Lake Avon Tributary 13	*Lake Avon Tributary 13 – Section A*	No	Not Undermined	270	Hawkesbury Sandstone	50	1	YES	34	285270	6194790	250	YES	420	LA13_P2	YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
Lake Avon Tributary 13	*Lake Avon Tributary 13 – Section B*	No	Undermined	270	Hawkesbury Sandstone	50	1	YES	34	285405	6194765	225	YES	20	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Lake Avon Tributary 13	*Lake Avon Tributary 13 – Section C*	No	Not Undermined	270	Hawkesbury Sandstone	100	3	YES	34	285410	6194755	325	YES	1260	LA13_P4 LA13_P9 LA13_P17	YES YES YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
Lake Avon Tributary 13	*Lake Avon Tributary 13 – Section D*	No	Undermined	305	Hawkesbury Sandstone	1450	17	YES	33	286485	6194650	525	YES	610	LA13_P50 LA13_ST3	NO NO	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Lake Avon Tributary 17	*Lake Avon Tributary 17 – Section A*	No	Not Undermined	300	Hawkesbury Sandstone	50	1	NO	57	283825	6195960	325	YES	300	Not Mapped	n/a	Not undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Cordeaux River																		
Cordeaux River Tributary 29	*Cordeaux River Tributary 29 – Section A*	No	Not Undermined	400	Hawkesbury Sandstone	150	1	YES	39	290465	6201100	425	YES	820	CR29_P4	YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
															CR29_P9 CR29_P35	YES YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
															CR29_P37	YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
															CR29_P40 CR29_Channel48	NO NO	Not undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Cordeaux River Tributary 29	*Cordeaux River Tributary 29 – Section B*	No	Undermined	415	Hawkesbury Sandstone	2300	16	YES	21	290950	6201265	350	YES	590	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Cordeaux River Tributary 31	*Cordeaux River Tributary 31 – Section A*	No	Not Undermined	375	Hawkesbury Sandstone	50	1	YES	48	290340	6199885	400	YES	490	CR31_P6 CR31_P10 CR31_P13 CR31_P18 CR31_P26 CR31_P30 CR31_P32 CR31_P33	YES YES YES YES YES YES YES YES	Not directly undermined – setbacks for key stream features as follows: • Greater than 50 m setback where longwall mining occurs on one side only. • Greater than 100 m setback where longwall mining occurs on two or more sides.	• Likelihood of impacts to Key Stream Features reduced through setbacks (MSEC, 2019). • Monitoring to confirm impacts avoided (Section 8 of EIS). • If physical damage occurs, remediation of stream features to be implemented (Section 7 of EIS). • Impact assessment has conservatively assumed loss of flow (HEC, 2019) and loss of aquatic ecology habitat (Niche, 2019) irrespective of setbacks, and therefore, biodiversity offset measures are proposed (Section 8 of EIS). • Impact assessment has conservatively assumed loss of surface water from these streams (HydroSimulations, 2019) irrespective of setbacks, and therefore, South32 would pay WaterNSW for any surface water loss from these streams to groundwater.
Cordeaux River Tributary 31C	*Cordeaux River Tributary 31C – Section A*	No	Not Undermined	385	Hawkesbury Sandstone	150	3	YES	39	291090	6199790	475	YES	280	None	None	Not undermined.	Likelihood of subsidence impacts reduced if not undermined (MSEC, 2019), otherwise, these non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Cordeaux River Tributary 31C	*Cordeaux River Tributary 31C – Section B*	No	Undermined	385	Hawkesbury Sandstone	525	7	YES	36	291120	6199825	400	YES	70	None	None	Undermined - No key stream features identified therefore no key stream feature offsets incorporated.	These non-key features would experience the full range of potential subsidence impacts (MSEC, 2019).
Cordeaux River	*Cordeaux River*	Yes	Not Undermined	375	Hawkesbury Sandstone	< 20	< 1	NO	49	290035	6200130	50	YES	0	Not Mapped***	n/a	Not undermined - Named stream setback incorporated to achieve no greater than 200 mm of additional predicted closure.	• Likelihood of subsidence impacts reduced to less than 10% for the short sections of these watercourses within 400 m of the longwalls (MSEC, 2019). ○ Cordeaux – 5% likelihood for 250 m section of river within 400 m of longwalls • Negligible likelihood of impact for the majority of the lengths of these watercourses beyond 400 m from the longwalls (MSEC, 2019).

^Refer to definition of 'Key Stream Features' in Section 6.2.
*Refer to Maps A - D;
**Percentage of Catchment Area for stream also includes percentage contribution of upstream tributaries, e.g. Stream AR19S includes the catchment contribution of Stream AR19S1
***not mapped as protected by named watercourse setbacks
Named Stream – setback to achieve 200 mm additional predicted closure or less
50 m offset for selected/ key stream features
100 m offset for selected/key stream feature
Additional stream section or non-key stream feature not undermined by EIS base case mine plan

Stream Matrix Definitions

No.	Item	Definition
1	River or Stream	Identifies the rivers and streams located above the extent of longwall mining area and within 600 metres (m) of the edge of secondary extraction. This includes relevant rivers as named on the Bargo, Bulli, Avon River and Wollongong 1:25,000 scale topographic mapping sheets (Department of Finance, Services and Innovation, 2018) and streams of second order or above according to the Strahler stream classification system. The locations of the streams are shown on Figure 1.
2	Maximum Strahler Stream Order	Maximum stream order determined in accordance with the Strahler stream classification system using the Bargo, Bulli, Avon River and Wollongong 1:25,000 scale topographic mapping sheets (Department of Finance, Services and Innovation, 2018).
3	Approximate Stream Length within Extent of Longwall Mining Area 35° Angle of Draw (km)	Length of stream within the extent of longwall mining area 35° angle of draw shown on Figure 1. Length given in kilometres (km). *Legend:* N/A = Stream not located within the extent of longwall mining area.
4	Approximate Stream Length within 600 m of Extent of Longwall Mining Area (km)	Length of stream within 600 m of the extent of longwall mining area shown on Figure 1.
5	Average Stream Gradient	The average stream gradient determined for each stream reach by calculating the change in elevation over the relevant reach and dividing by the length of the reach. Gradient given in metres per kilometre (m/km). Note: stream profiles for a selection of streams are shown on long sections provided in Attachment 6.
6	Geomorphic Type	A geomorphic classification has been developed by HEC to characterise the geomorphic attributes of the streams. The classification scheme has been based loosely on the River Styles framework as described in the paper by Brierley et al. (2002). The classification scheme is based on four groups of geomorphic attributes, namely: valley type; floodplain development; bed materials and mobility; and dominant physical features. *Legend:* <u>Valley Type:</u> V1 = Confined. V2 = Partially Confined. V3 = Alluvial. <u>Floodplain Development:</u> FP1 = No floodplains. FP2 = Irregular floodplain and floodplain pockets less than 25% of stream fringed by floodplains. FP3 = Moderate floodplain development – between 25% and 75% of stream fringed by floodplains.

No.	Item	Definition
		FP4 = High floodplain development – greater than 75% of stream fringed by floodplains. Bed Materials and Mobility: B1 = Bedrock comprising rock outcrop or boulderfield beds with no or minimal/infrequent mobile sediments in some sections. B2 = Sand bed comprising cohesionless sandy sediments. B3 = Cohesive bed comprising silty, sandy bed materials with significant cohesion and/or organic materials. Dominant Physical Features: DF1 = Pools and rockbars and chutes. DF2 = Cascades and waterfalls. DF3 = Boulderfields. DF4 = Pools and riffles in alluvial/mobile streams. DF5 = Uniform streams with no or insignificant pool development. DF6 = Swamps and/or chain of ponds wide shallow streams with significant in-stream vegetation and persistent swamps or wide shallow pools with ill-defined channels. In applying the classification scheme to the stream reaches, the classification which is dominant over the full length of the stream reach has been selected.
7	Key In-Stream/Visual Amenity Features (e.g. riffles, pools, etc.)	Identifies key in-stream/visual amenity features based on stream mapping provided in Attachment 1.
8	Stream Catchment Area (km2)	Catchment area based on the total upstream catchment area reporting to the downstream point of each stream reach. Catchment area given in square kilometres (km^2).
9	Permanence of Flow (Perennial vs Intermittent)	Categorises the permanence of flow of each stream reach. Streams were categorised as perennial or intermittent based on the mapping of perennial watercourses on the 1:25,000 scale topographic maps produced by the NSW Department of Information Technology and Management – Land Information Centre.
10	Stream Regulation History	Identifies whether any WaterNSW-controlled dams and/or weirs are known to be situated upstream of the stream reaches, namely, the Avon Dam and Cordeaux Dam. *Legend:* N = No. Y = Yes.
11	Importance to Catchment Yield - Percentage of Avon River Catchment Area	The significance of each stream reach to the catchment of the Avon River presented as a percentage. Calculated by dividing the catchment area of the stream reach [Item 9] by the catchment area of the Avon River (174 km^2).
12	Importance to Catchment Yield - Percentage of Donalds Castle	The significance of each stream reach to the catchment of Donalds Castle Creek presented as a percentage. Calculated by dividing the catchment area of the stream reach [Item 9] by the catchment area of Donalds Castle Creek (14 km^2).

No.	Item	Definition
	Creek Catchment Area	
13	Importance to Catchment Yield - Percentage of Avon Dam Catchment Area	The significance of each stream reach to the Avon Dam Catchment presented as a percentage. Calculated by dividing the catchment area of the stream reach [Item 9] by the catchment area of the Avon Dam (143 km^2).
14	Importance to Catchment Yield - Percentage of Cordeaux River Catchment Area	The significance of each stream reach to the catchment of the Cordeaux River presented as a percentage. Calculated by dividing the catchment area of the stream reach [Item 9] by the catchment area of the Cordeaux River (681 km^2)
15	Environmental Quality (Observed/Existing Disturbance)	Provides a qualitative assessment of the environmental quality of the stream reach based on known disturbances in consideration of the information provided in the Biodiversity Assessment (Appendix D of the EIS) and the inspection of aerial photographs available on Google Earth. *Legend:* P = Pristine - majority of vegetation within upstream catchment is intact, limited disturbances within catchment area (e.g. fire tracks, exploration activities). M = Modified - majority of riparian vegetation intact, agricultural/other disturbances within catchment areas. SM = Severely Modified - moderate to high disturbance of riparian vegetation, agricultural/other disturbances to catchment area and/or disturbance to channel/flow (e.g. weirs, dams, discharges).
16	Flora and Fauna Survey Sites	The flora, fauna and aquatic surveys for the Project included representative sampling of stream and adjacent riparian and/or gully habitats. The flora, fauna and aquatic survey sites on or adjacent to the stream reaches are identified. Aquatic ecology survey sites have been included for the stream reach in which they were conducted. Terrestrial flora survey sites have been included on the basis of being located within the riparian zone of a stream reach. Terrestrial fauna survey sites have been included on the basis of being located either in the stream (water habitat) or adjacent to the stream either in riparian or gully forest habitat). Details of the survey methodologies are provided in the Aquatic Ecology Assessment (Appendix E of the EIS) and the Biodiversity Assessment (Appendix D of the EIS). *Legend:* - = No survey sites within the water habitat of the stream or in the riparian zone <u>Fauna</u> FT = Targeted Survey Site <u>Flora</u> FLB = Bio-Banking Plot Site FLR = Rapid Data Point Site <u>Aquatic Ecology</u> AQ = Aquatic Ecology Sampling Site
17	EECs Present in Riparian Zone	Identifies vegetation communities identified within the riparian zone of stream reaches that represent Endangered Ecological Communities (EECs) listed under the NSW Threatened Species Conservation Act, 1999 (TSC Act) or Commonwealth

No.	Item	Definition
		Environment Protection and Biodiversity Conservation Act, 1999 (EPBC Act) (Appendix E of the EA) (as at 1 July 2009). *Legend:* MU44b = Upland Swamps: Restiod Heath (EEC) MU44c = Upland Swamps: Cyperoid Heath (EEC) MU43 = Upland Swamps: Tea-tree Thicket (EEC) MU42 = Upland Swamps: Banksia Thicket (EEC) - = riparian vegetation does not represent any Endangered Ecological Communities listed under the TSC Act or EPBC Act
18	Key Fish Habitat Type	Identifies the type of Key Fish Habitat Legend: Type 1 = Highly Sensitive Type 2 = Moderately Sensitive
19	Threatened Species Recorded during Project Surveys and/or Described in Aquatic Ecology Assessment - Records within Streams	Identifies threatened species recorded in streams by the Project surveys. *Legend:* GD = Giant Dragonfly - = no threatened species records from Project surveys or historic records as described in the Aquatic Ecology Assessment.
20	Threatened Species Recorded during Project Surveys and/or Described in Aquatic Ecology Assessment - Records Adjacent to Stream in Riparian or Gully Habitats	Identifies threatened species recorded in riparian and/or gully habitats adjacent to the stream reaches by the Project surveys. Threatened flora species records have been included on the basis of being located within the riparian zone of a stream reach. Threatened fauna species records have been included on the basis of being located either in riparian or gully forest habitat adjacent to the stream reach. *Legend:* EBB = Eastern Bentwing-bat LJT = Littlejohn's Tree Frog RG = Rosenberg's Goanna GBB = Greater Broad-nosed Bat - = no threatened species records from Project surveys
21	Land Zoning	Identifies the zoning of land within which the stream reaches are situated according to the Local Environmental Plan maps for the Wollondilly Shire and Wingecarribee Shire Councils. *Legend:* WC = Water Catchment
22	Public Accessibility	Identifies stream reaches that are accessible to the public (i.e. none, as all streams are within the Metropolitan Special Area).
23	Stream Photos	Refers to plates with aerial view and photographs for a selection of stream reaches, included in Attachment 3.

No.	Item	Definition
24	Stream Mapping	Refers to stream mapping of each reach provided in Attachment 1. The stream mapping identifies key in-stream/visual amenity features. Legend: - = Stream mapping not provided in Attachment 1.
25	Stream Risk Management Zone	Refers to Plans showing the Risk Management Zone applied to each stream reach.
26	River or Significant Stream Section	Categorises the river or significant stream section with consideration of predicted subsidence effects.
27	Named?	Identifies the streams that are named on the Bargo, Bulli, Avon River and Wollongong 1:25,000 scale topographic mapping sheets (Department of Finance, Services and Innovation, 2018). *Legend:* N = No. Y = Yes.
28	Undermined/ Not Undermined	Identifies if a river or significant stream section is undermined or not undermined by a longwall.
29	Minimum Depth of Cover Above Mining Area (m)	The minimum depth of cover between each stream reach and the underlying coal seam within the mining area. The values for streams that are located outside the mining area are the minimum depths of cover above the mining area where it is located closest to the stream.
30	Geological Formation	Geological formation within the stream bed as shown on DPI Geological Series Sheet 9029-9129.
31	Conventional Subsidence Parameters - Total Maximum Predicted Subsidence (mm)	Maximum predicted vertical movement of a point at the surface in millimetres (mm). Refer to the Subsidence Assessment (Appendix A of the EIS) for further detail.
32	Conventional Subsidence Parameters - Total Maximum Predicted Tilt (mm/m)	Maximum predicted change in the slope of the land surface as a result of differential subsidence, where 1 millimetre per metre (mm/m) is equivalent to 0.1% change in grade. Refer to the Subsidence Assessment (Appendix A of the EIS) for further detail.
33	Stream Long Section - Tilt and Grade	Refers to a figure included in the Subsidence Assessment (Appendix A of the EIS) which shows the tilt [Item 30] and the change in grade across a long section along the stream. Legend: - = Long section showing tilt and grade not completed for this stream.
34	Maximum Equivalent Valley Height (MEVH) (m)	The average height of the two valley sides above the base of the valley, within a distance from the base of the valley equal to half the depth of cover at the base of the valley. Refer to the Subsidence Assessment (Appendix A of the EIS) for further detail.
35	Easting (at MEVH)	Coordinate taken at point along stream with MEVH [Item 31] in MGA (Zone 56).

No.	Item	Definition
36	Northing (at MEVH)	Coordinate taken at point along stream with MEVH [Item 31] in MGA (Zone 56).
37	Non-Conventional Subsidence Parameters - Maximum Predicted Upsidence (mm)	The maximum predicted reduced subsidence, bulging or net uplift movement within the base of a valley. Refer to the Subsidence Assessment (Appendix A of the EIS) for further detail.
38	Non-Conventional; Subsidence Parameters - Maximum Predicted Closure (mm)	The maximum predicted reduction in the horizontal distance between the valley sides. Refer to the Subsidence Assessment (Appendix A of the EIS) for further detail.
39	Stream Long Section - Equivalent Valley Height, Upsidence and Closure	Refers to a figure included in the Subsidence Assessment (Appendix A of the EIS) which shows the equivalent valley height [Item 31], upsidence [Item 34] and closure [Item 35] across a long section along the stream. Legend: - = Long section showing equivalent valley height, upsidence and closure not completed for this stream.
40	Length of Stream with greater than 200 mm Closure (km)	Total length of stream reach that is predicted to be subject to closure greater than 200 mm [Item 35].
41	Mapped Stream Features	Stream features identified by South32 surveys as labelled on Maps 01-04 that meet the following criteria: • Pools > 100 m^3 but were not 'dry' upon inspection; and • Waterfalls/Steps > 5 m height and with a 'plunge-pool' located at the base.
42	Identified as Key Stream Features	Those stream features identified that were located in close proximity to the proposed longwalls and hence additional setbacks from these 'key' stream features from the longwalls were incorporated.
43	Subsidence Impact Summary	Summary of the key stream feature setbacks incorporated.
44	Subsidence Impact Assessment	Summary of potential impacts in consideration of aquatic ecology and biodiversity.