Memorandum

To:	Cody Brady	**At:**	South 32 - Illawarra Metallurgical Coal
From:	Arash Mohajeri	**At:**	SLR Consulting Australia Pty Ltd
Date:	24 January 2023	**Ref:**	66510015.00004-M01-v3.0-20230125.docx
Subject:	Appin Mine Extraction Plan Groundwater Impact Assessment Department of Planning and Environment Review Comments		

The Appin Mine is located approximately 25 km north-west of Wollongong. Appin Mine is owned and operated by Illawarra Metallurgical Coal (IMC), a subsidiary of South32 Limited (South32). Heritage Computing (2009) conducted the groundwater impact assessment for the approved operations relevant to the assessment of proposed longwall mining at the Bulli Seam Operations (BSO). SLR Consulting Australia Pty Ltd (SLR) was engaged by South32 to complete a groundwater assessment to support the Extraction Plan application for the Longwalls 709, 710A, 710B, 711 and 905 (the Project).

The Appin Mine Extraction Plan Groundwater Assessment Report (665.10015-R03-v8.0-20220928) was completed and provided for review on 29 September 2022 SLR (2022). This memo provides responses to the Department of Planning and Environment requesting additional information comparing the revised groundwater impacts discussed in SLR (2022) against the originally assessed and approved groundwater impacts in the Bulli Seam Operations Project groundwater assessment prepared by Noel Merrick (Heritage Computing, 2009).

1 Introduction

Since Heritage Computing (2009) groundwater impact assessment for the BSO Project, the groundwater model for the Appin Mine has gone through several significant updates. It is expected that some of the predictions from the SLR 2022 report are different to the model predictions from Heritage Computing built in 2009. Some of the model updates included:

- Modelling Software: Updated from MODFLOW-SURFACT to MODFLOW-USG;
- MODFLOW packages: All packages updated to be compatible with MODFLOW-USG. Landowner pumping and coal seam gas (CSG) extractions (Camden Gas project) were incorporated into the model. The landowner pumping and CSG exclusion from the 2009 model was possibly due to lack of any available data at the time of the model construction in 2009.
- Model Structure: Updated with the latest geology model for the site, the Sydney Basin geology model, and topography.
- Model Structure: Increase in model vertical resolution in the Hawkesbury Sandstone and the Bulgo Sandstones.
- Model timing: decrease in model time slice lengths (from annual to quarterly).
- Updates to mine progression at Appin and the neighbouring mines to reflect change to the operation than originally planned.
- Updates in simulation of the fracture profile to include Ditton Zone B and the surface fracturing. Heritage Computing (2009) model did not simulate these two zones due to the complications associated with changing the model properties in MODFLOW-SURFACT.
- Update in calibration data set. The updated calibration data set is significantly larger comparing to the 2009 groundwater model as it includes measurement from the new boreholes that have been established since 2009, in addition to the subsequent monitoring data that has been collected in the exiting bores since 2009.
- Recalibration: The 2009 groundwater model only included a steady state calibration. The SLR (2022) used the updated calibration data set and recalibrated the model to the pre-mining levels (steady state) and also to transient responses to the stresses (e.g. mining and climate) to the groundwater system (Transient calibration). The recalibration resulted in changes in hydraulic properties in the model. The transient calibration also allowed the storage parameters in the model to be adjusted. The 2022 recalibration was guided by the hydraulic conductivity measurements at Appin and the neighbouring mine.

The following sections compare the groundwater impacts discussed in SLR (2022) against the originally assessed and approved groundwater impacts predicted by Heritage Computing (2009).

2 Predicted Mine Inflows

Figure 1 compares the predicted mine inflow for Appin Area 7 predicted in the SLR (2022) groundwater model and Heritage Computing (2009) groundwater model. As shown in the figure, the magnitude of the predicted mine inflows from SLR (2022) are consistent with the Heritage Computing (2009) predictions and the measured inflows for Appin Area 7. Prior to 2016 the SLR (2022) model predicts higher inflows comparing to Heritage Computing (2009). After 2016 this trend is reversed. The difference in the simulated inflows is likely due to updates to the simulation of the fracture zone, updates to the model structure and the updates to the calibrated hydraulic properties based on more recent observation data.

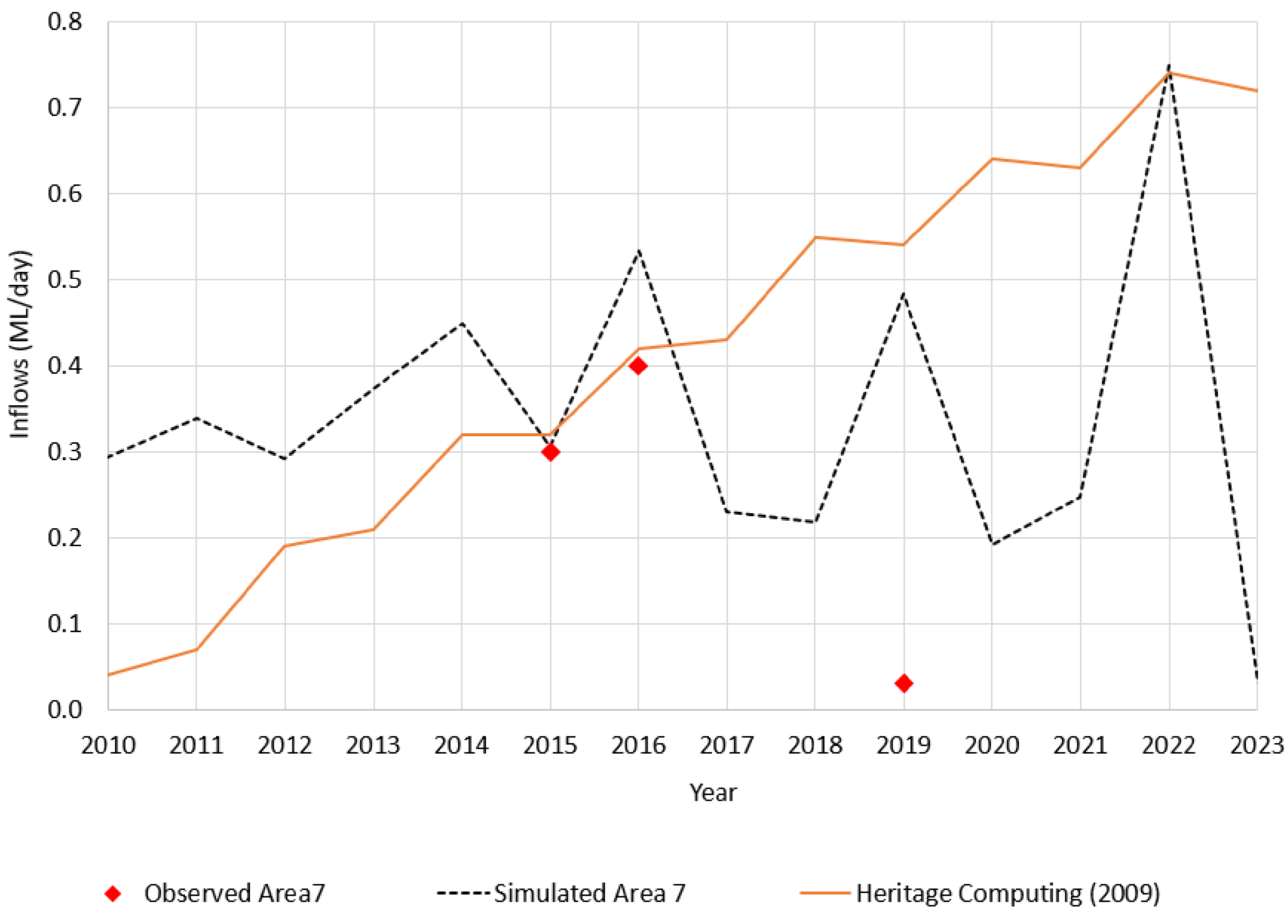

Figure 1 Simulated Mine Inflows- Appin Area 7

3 Simulated Drawdowns

Figure 2, **Figure 4**, and **Figure 6** compare the predicted cumulative drawdown from the SLR (2022) model against the Heritage Computing (2009) model for the Middle Hawkesbury Sandstone, Lower Hawkesbury Sandstone and Upper Bulgo Sandstone. In all the figures, the predicted drawdowns from SLR (2022) shown with the black dash line in the figures are overlaid with the maps from the Heritage Computing (2009) report.

The Heritage Computing (2009) report did not present the predicted incremental drawdown and predicted cumulative drawdown in the Alluvium and Bulli Seam. Therefore, these predictions, which were reported in SLR (2022) report, could not be compared to Heritage Computing (2009) report.

Figure 2, **Figure 4**, and **Figure 6** show that the shape and extent of the predicted maximum cumulative drawdown immediately around the Appin Mine footprint are consistent with the impact assessment conclusions for the Bulli Seam Operations (BSO) by Heritage Computing (2009). However, further away from the Appin Mine, the SLR (2022) predicts larger extent and different shape of cumulative drawdown in a few areas.

Figure 2 shows that in Middle Hawkesbury Sandstone, the SLR (2022) model predicted larger drawdown extent to the northwest of the mine (highlighted with the red rectangle in the figure). The predicted drawdown in this area of the model is likely due to the pumping at the landowner bores which were simulated in the SLR (2022) model but were not included in the Heritage Computing (2009) model.

Although the cumulative impacts in some areas (as shown in **Figure 2**, **Figure 4**, and **Figure 6)** are larger in the SLR model than the Heritage Computing (2009) model, the predicted impacts due to the Appin Mine demonstrate that the differences in predicted impacts are likely associated with landowner pumping, CSG extraction and the mining at the neighbouring mines (Tahmoor and Metropolitan). These are shown in **Figure 3**, **Figure 5** and **Figure 7** where predicted incremental drawdown due to Appin (SLR, 2022) is compared with the predicted cumulative drawdowns from SLR (2022).

Figure 3, **Figure 5** and **Figure 7** show the extents of predicted drawdown due to mining at Appin are less extensive with the cumulative drawdown predicted by Heritage Computing (2009) when the impacts from landowner pumping, CSG extraction and the neighbouring mine are removed. Therefore, any additional environmental consequences (such as drawdown in HBSS) a result of mining at Appin is likely to be negligible.

The different shape of cumulative drawdown away from the Appin Mine predicted is due to the updates to the simulation of the fracture zone which allowed more vertical propagation of drawdowns at Appin and also in the neighbouring mines, updates to the model structure and the updates to the calibrated hydraulic properties based on more recent observation data (**Figure 2**, **Figure 4** and **Figure 6)**.

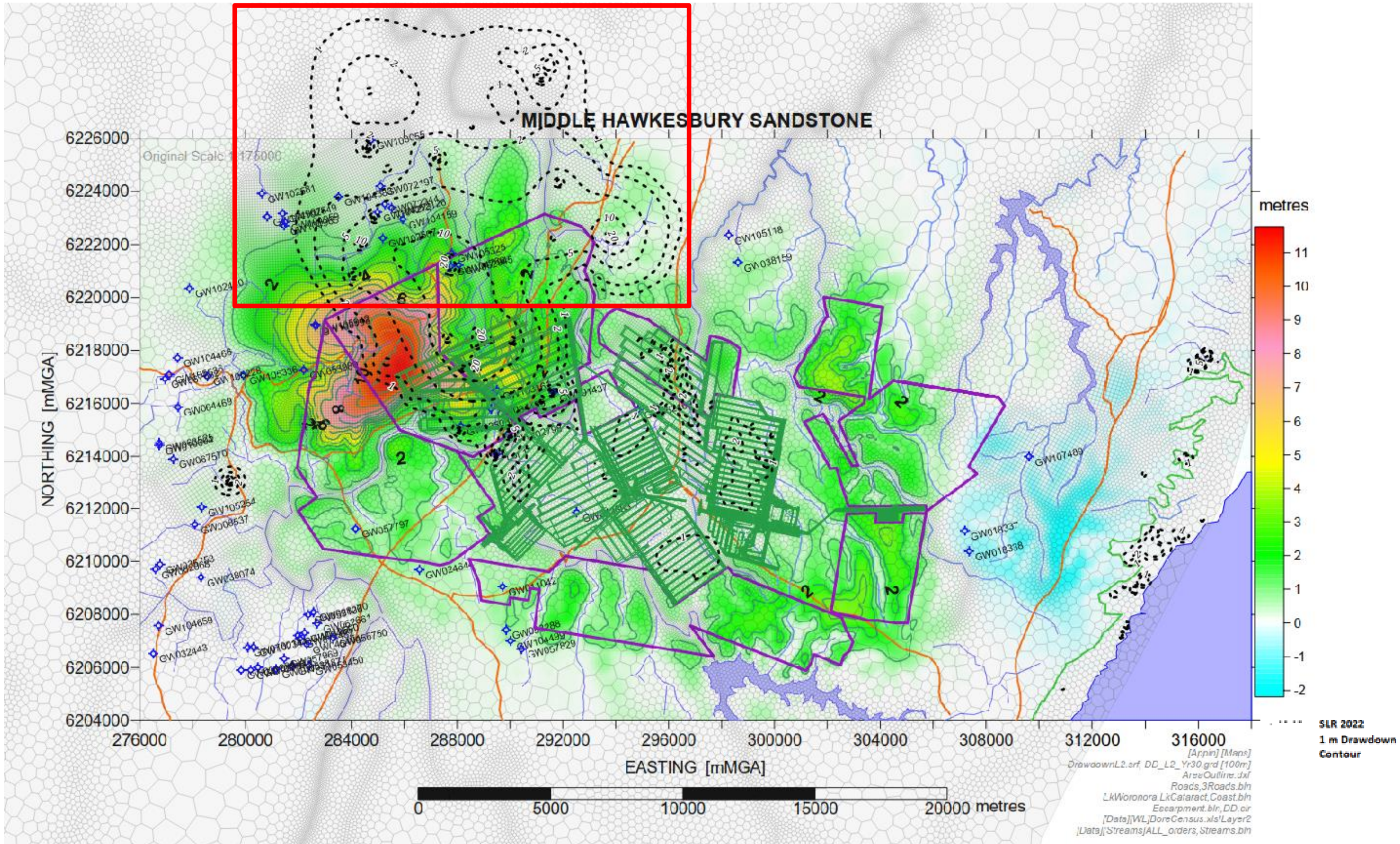

Figure 56. Predicted drawdown in the middle Hawkesbury Sandstone in relation to registered production bores after 30 years of mining.

Figure 2 Simulated Cumulative Drawdown – Middle Hawkesbury Sandstone

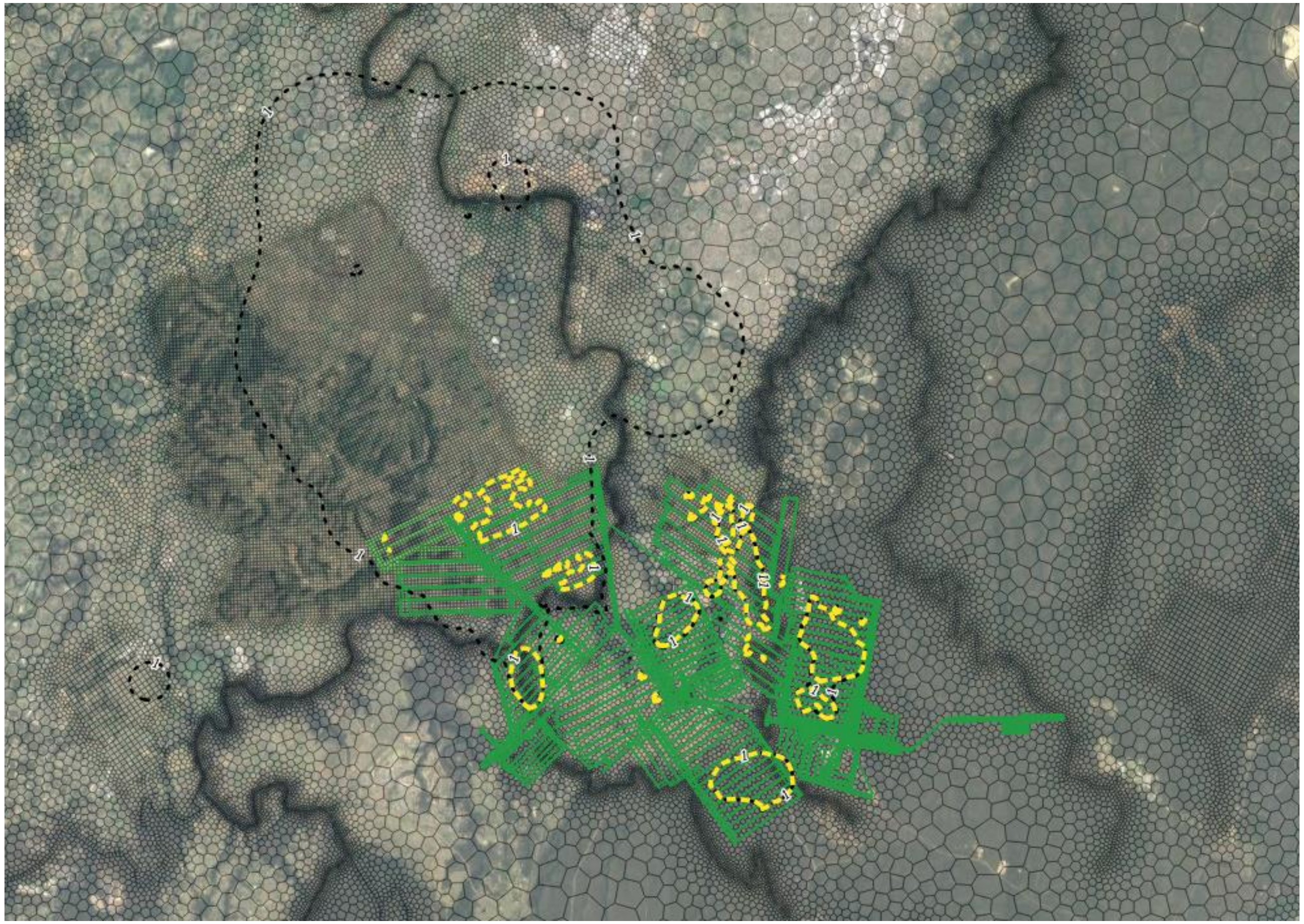

Figure 3 Simulated Cumulative Drawdown (SLR 2022) comparing to Incremental Drawdown Due to Mining at Appin (SLR 2022) – Middle Hawkesbury Sandstone

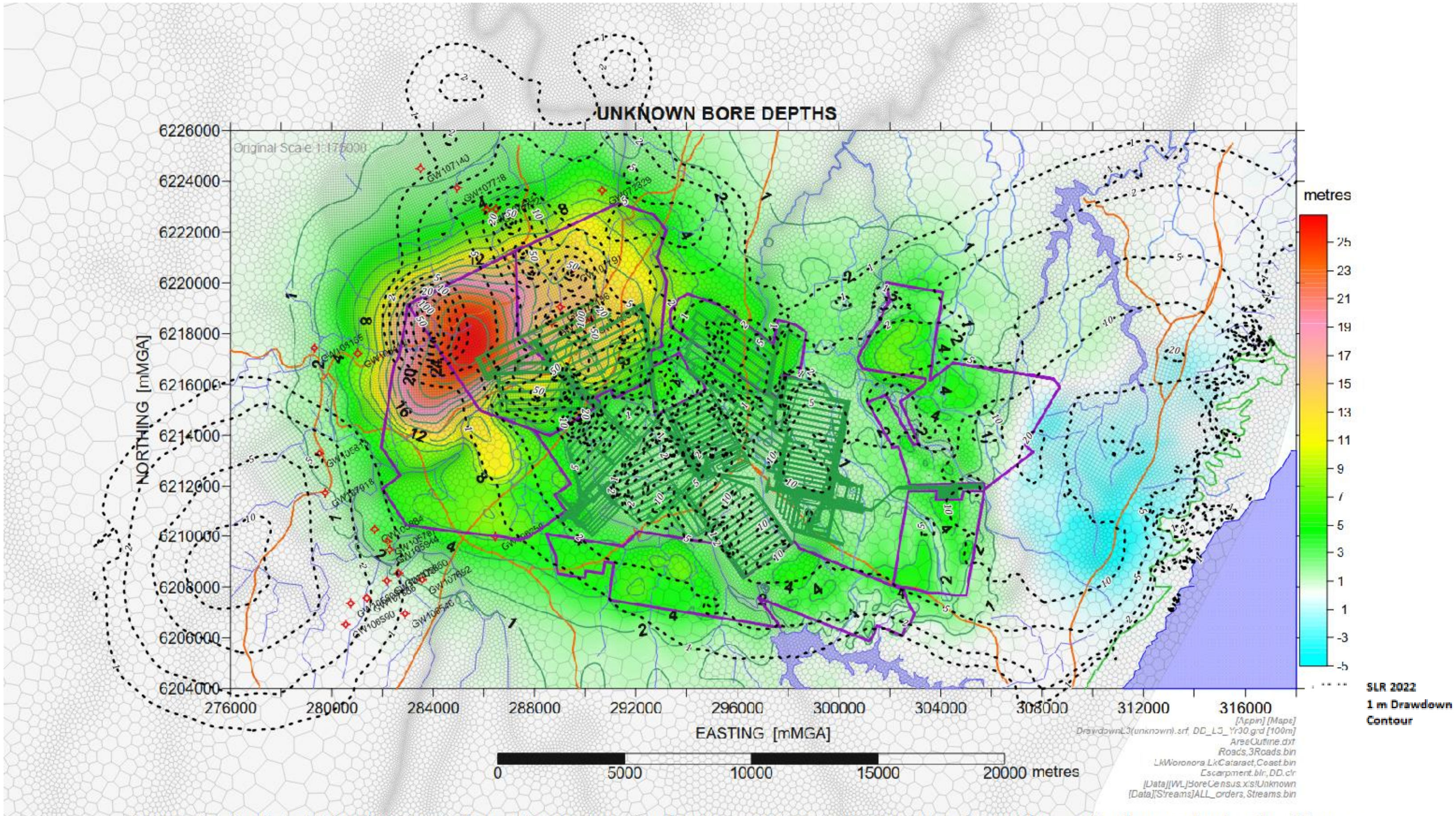

Figure 59. Predicted drawdown in the lower Hawkesbury Sandstone in relation to registered production bores of unknown depth, after 30 years

Figure 4 Simulated Cumulative Drawdown – Lower Hawkesbury Sandstone

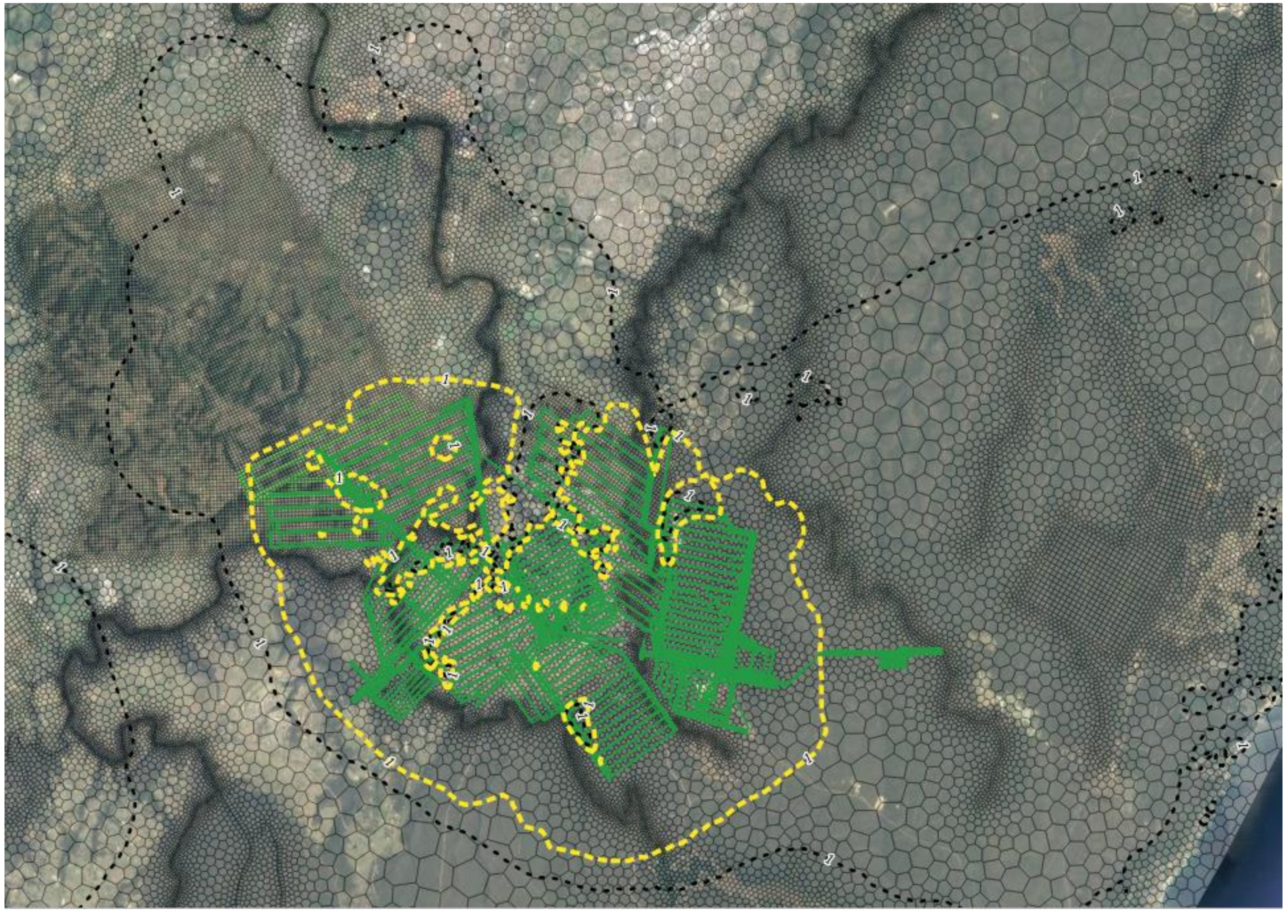

Figure 5 Simulated Cumulative Drawdown (SLR 2022) comparing to Incremental Drawdown Due to Mining at Appin (SLR 2022) – Lower Hawkesbury Sandstone

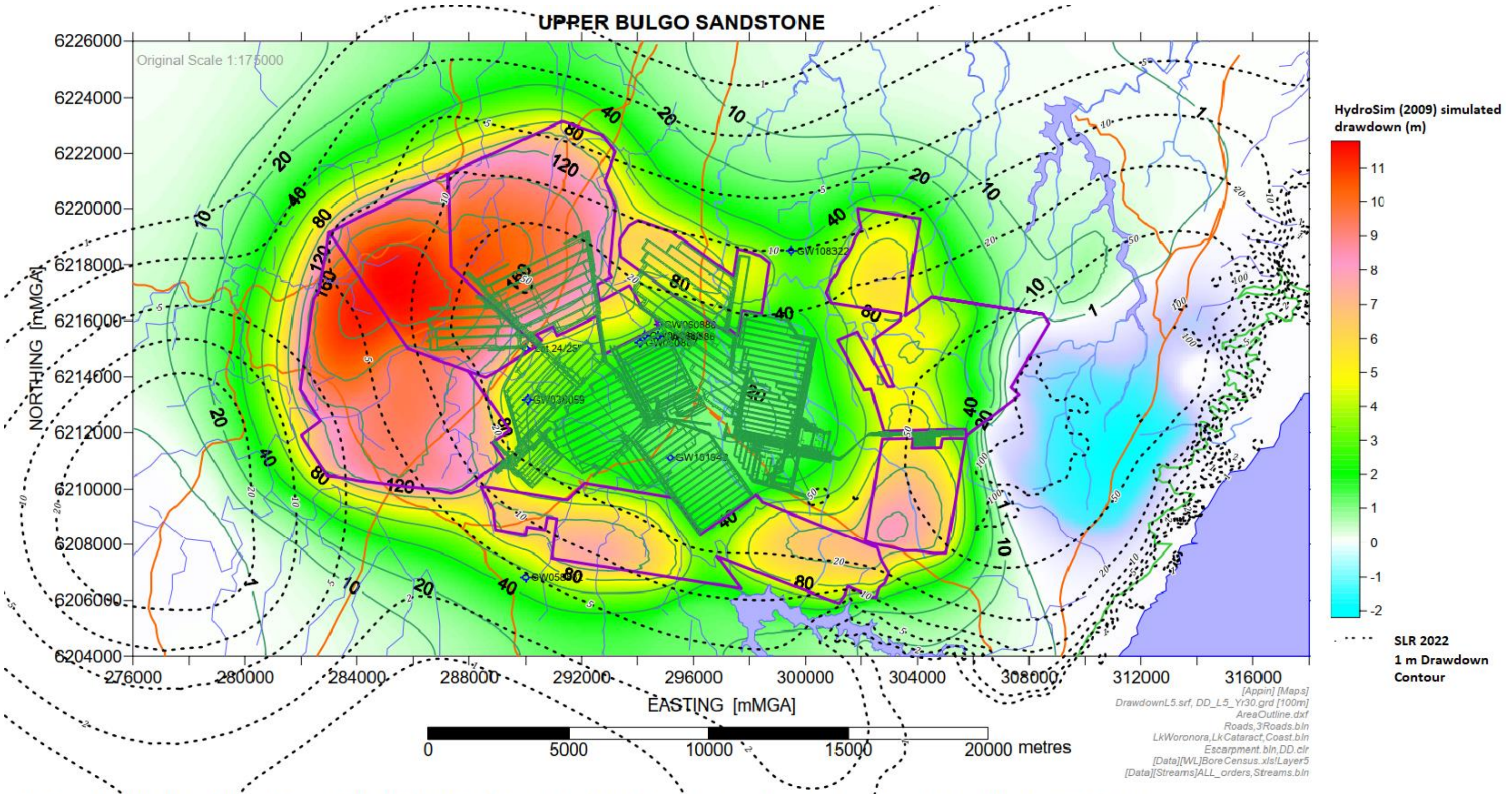

Figure 58. Predicted drawdown in the Bulgo Sandstone in relation to registered production bores after 30 years of mining.

Figure 6 Simulated Cumulative Drawdown – Upper Bulgo Sandstone

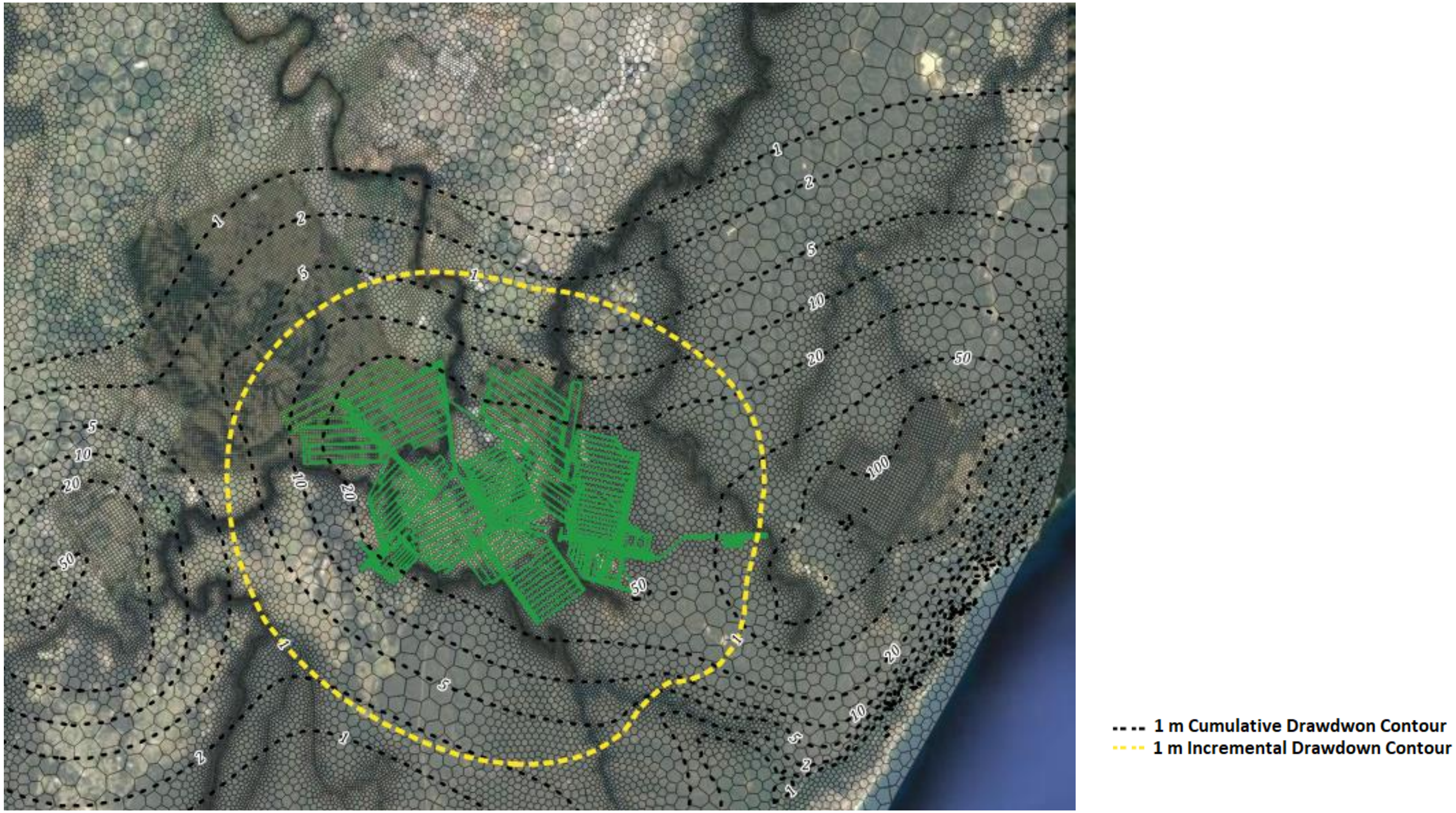

Figure 7 Simulated Cumulative Drawdown (SLR 2022) comparing to Incremental Drawdown Due to Mining at Appin (SLR 2022) – – Upper Bulgo Sandstone

4 Predicted Depressurisation at Landholder Bores within the EP Study Area:

Table 1 compares the predicted cumulative depressurisation from the SLR (2022) model to the results reported in Heritage Computing (2009) at landholder bores within the Extraction Plan (EP) study area. The predicted incremental depressurisations were not reported in the Heritage Computing (2009). The bores with unknown geology were assumed to be in the Lower Hawkesbury Sandstone. In several bores, the predicted cumulative depressurisations from the SLR (2022) model show much larger values compared to the predictions from Heritage Computing (2009).

The difference in predictions between the two models are likely due to the landowner pumping and CSG extraction simulated in SLR (2022), the updates to the simulation of the fracture zone(i.e., inclusion of Ditton Zone B and surface fracturing), updates to the model structure (i.e., updated geology model and vertical resolution) and the updates to the calibrated hydraulic properties based on the larger calibration data set and more recent observation data.

Table 1 also shows the contribution of mining activities at Appin towards the predicted cumulative drawdown. As it can be seen in **Table 1**, with the exception of GW106574, GW105376, GW105574 and GW105534, SLR (2022) predicted insignificant contribution from mining at Appin towards the predicted cumulative drawdown predicted at the Landholder bores.

Table 2 shows additional landholder bores that SLR (2022) predicted to experience cumulative drawdowns more than 2 m. These bores were not included in the Heritage Computing (2009) report.

Table 1 Predicted Depressurisation at Landholder Bores

Work ID	Bore Type / Role	Geology	Maximum Depressurisation (m) - Cumulative	Maximum Depressurisation (m) - due to Appin Mine	Incremental Maximum Depressurisation (m) - due to the Project	Cumulative Maximum Depressurisation (m)- Heritage Computing (2009)
GW102043	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone, Siltstone and Clay from Open Hole to TD.	119.6	0.0	0.2	4.0
GW104068	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone, Siltstone and Shale from Open Hole to TD	92.3	0.0	0.6	4.0
GW105942	Test Bore (BH Reg); MON (NGIS)	Shale and Clay from Open Hole to TD	0.0	0.0	0.0	6.0
GW108193	Test Bore (BH Reg); MON (NGIS)	Clay and Shale from Open Hole to TD	0.0	0.0	0.0	6.0
GW104154	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	36.0	0.0	0.0	8.0
GW104602	Stock (BH Reg); STOK (NGIS)	Sandstone and Claystone from Open hole to TD	135.7	0.0	0.1	10.0
GW104661	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone from Open Hole to TD	115.6	0.5	0.2	11.0
GW105339	Stock, Domestic, Irrigation (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	1.6	0.0	0.0	12.0
GW108312	Test Bore (BH Reg); INDS (NGIS)	Sandstone from Slots and Open Hole to TD	3.4	0.1	0.0	12.0
GW102619	Stock, Domestic, Irrigation (BH Reg); IRAG (NGIS)	Sandstone and Shale from Open Hole to TD	38.5	0.0	0.0	14.0

Work ID	Bore Type / Role	Geology	Maximum Depressurisation (m) - Cumulative	Maximum Depressurisation (m) - due to Appin Mine	Incremental Maximum Depressurisation (m) - due to the Project	Cumulative Maximum Depressurisation (m)- Heritage Computing (2009)
GW105376	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone from Open Hole to TD	184.3	11.0	11.1	14.0
GW105388	Stock, Domestic	Sandstone from Open Hole to TD	196.3	0.3	0.2	14.0
GW105534	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Slate from open hole to TD	24.5	4.9	6.7	14.0
GW105574	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone, Clay and Shale from Surface	174.6	9.6	9.7	14.0
GW106574	Domestic	Sandstone from Open Hole to TD	62.3	29.1	29.5	14.0
GW107791	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone from Open Hole to TD	186.3	0.0	0.1	14.0
GW106675	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	39.6	0.0	0.0	15.0
GW108907	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	139.2	0.0	0.2	15.0
GW105531	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone and Shale from Open Hole to TD	40.8	0.0	0.0	16.0

Table 2 Additional Landholder Bores with predicted Cumulative Drawdowns Greater than 2m – SLR (2022)

Work ID	Bore Type / Role	Geology	Maximum Depressurisation (m) - Cumulative	Maximum Depressurisation (m) - due to Appin Mine	Incremental Maximum Depressurisation (m) - due to the Project
GW072874	Stock, Domestic (BH Reg); HUSE (NGIS)	Sandstone, Siltstone and Shale from Open Hole to TD	26.8	6.2	7.8
GW112481	Industrial	Unconsolidated Clay/Silt	485.4	3.9	5.7

5 Conclusions

The SLR (2022) groundwater model predictions were compared against the Heritage Computing (2009). The Heritage Computing (2009) was built to support the Bulli Seam Operations Project groundwater assessment.

The SLR (2022) groundwater model included significant updates compared to the Heritage Computing (2009) model. The SLR (2022) model calibration used a much more comprehensive groundwater data base and included both steady state and transient calibration. The SLR (2022) model also included the CSG extraction and landowner pumping, which were not simulated in the Heritage Computing (2009) model.

The simulated inflows predictions were generally consistent with the predictions from the Heritage Computing (2009) model. The simulated cumulative drawdowns from SLR (2022) were larger in some areas compared to the Heritage Computing model predictions. However, the larger zones of impact simulated in the SLR (2022) model are associated with the landowner pumping and CSG extraction and more drawdown predicted in the neighbouring mines. When predicted incremental drawdown due to mining at the Appin Mine were compared against the Heritage Computing (2009), the zone of predicted impact from SLR (2022) were less extensive.

The additional data and updates made in the SLR (2022) groundwater model resulted in changes to the model predictions compared to the Heritage Computing (2009) model. However, comparing the results between the two models show any additional environmental consequences (e.g. drawdown in HBSS and landowner bores) as a result of mining at Appin is likely to be negligible. Where the predictions are different, they are mainly a result of the non-Appin related stresses (CSG extraction, landowner pumping, mining at the neighbouring mines) rather than mining activities at Appin. Some of these stresses were not simulated in the Heritage Computing (2009).

Checked/
Authorised by: BR