APPENDIX C
GROUNDWATER ASSESSMENT

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DATE:	28 May 2014
TO:	Jamie Lees Manager - Project Development and Approvals Wilpinjong Coal Pty Ltd
	c/- Resource Strategies Pty Ltd Suite 2, Level 3, 24 McDougall Street MILTON QLD 4064
FROM:	Noel Merrick
RE:	Wilpinjong Coal Mine Modification 6 – Groundwater Assessment
OUR REF:	WIL007 - HC2014/008

INTRODUCTION

Wilpinjong Coal Pty Ltd (WCPL) commissioned HydroSimulations to provide an assessment of the groundwater impacts of the proposed Modification 6 to the Wilpinjong Coal Mine. The Wilpinjong Coal Mine is located in the Western Coalfield of New South Wales (NSW), almost 40 kilometres (km) northeast of the town of Mudgee. **Figure 1** presents the location of the Wilpinjong Coal Mine in the context of regional geology (Colquhoun *et al.,* 1999) and nearby Groundwater Management Areas (GMAs) and mapped Biophysical Strategic Agricultural Land (BSAL). There is no BSAL mapped within or near to the Wilpinjong Coal Mine.

HydroSimulations previously carried out the Groundwater Assessment in support of Modification 5 (HydroSimulations, 2013). Most relevant to groundwater, Modification 5 included extensions to a number of the open cut pits. Modification 5 was approved by the NSW Planning Assessment Commission in February 2014. The general arrangement of the approved mine, including the definition of the six main pits, is shown on **Figure 2**. This also shows the relationship between the mine and nearby main watercourses and surrounding outcrop geology.

In this area water resources are currently managed under one Water Sharing Plan (WSP). The Wilpinjong Coal Mine lies within the 'Wollar Creek Water Source' of the Goulburn Extraction Management Unit which is governed by the *Hunter Unregulated and Alluvial Water Sources WSP* and the *Water Management Act 2000*. This plan does not cover non-alluvial groundwater systems.

The hardrock areas are covered by the Sydney Basin – Upper Hunter GMA which is to be governed by the *North Coast Fractured and Porous Rock Groundwater Sources WSP*; however, this WSP is currently under development by the NSW Office of Water (NOW). Therefore licensing of the water take from the coal seams and adjacent hardrock remains governed by Part 5 of the *Water Act 1912*.

The *NSW Aquifer Interference Policy* (the AI Policy) (NSW Government, 2012) establishes minimal impact considerations for 'Highly Productive' and 'Less Productive' groundwater. Based on information received from NOW (dated June 2013), 'Highly Productive' groundwater is restricted to the alluvium associated with the Wollar Creek Water Source, i.e. along reaches of Wilpinjong Creek (below the confluence with Cumbo Creek) and Wollar Creek. At its closest this is about 200-300 metres (m) northeast (downstream) of Wilpinjong Coal Mine (see **Figure 2**). The hardrock is classified as 'Less Productive'. As shown on **Figure 1**, the Moolarben Coal Complex and the Ulan Mine Complex are operated nearby.

The Groundwater Assessment for the Modification 5 open cut extensions utilised 3D groundwater flow modelling, using MODFLOW-SURFACT, to estimate inflows to the open cut mine pit and carry out impact assessment for nearby groundwater users, baseflow-fed watercourses and other water features.

An assessment against the minimal impact considerations in the AI Policy was conducted by HydroSimulations (2013). The assessment concluded that Modification 5 was within the 'Level 1' minimal impact considerations outlined in the AI Policy.

Modification 6

Since transitioning to an owner-operator mine in 2013, WCPL has been implementing a continuous improvement programme for materials handling/mining. The outcomes of this programme indicate a higher ROM coal production rate could be achieved with only minor changes to the existing mining fleet. An increased rate of annual ROM coal production would provide operational flexibility to maintain WCPL's competitive advantage as a low cost thermal coal producer.

WCPL has determined that a number of minor alterations to the approved Wilpinjong Coal Mine are therefore required, including:

- An increase in the upper rate of ROM coal production (from 15 million tonnes per annum [Mtpa] to approximately 16 Mtpa).
- A minor increase in the upper annual rate of waste rock production (from 33.3 million bank cubic metres [Mbcm] to approximately 34.1 Mbcm).
- Mine sequencing revisions associated with updated geological modelling/mine planning and the accelerated re-mining of a temporary waste rock emplacement.

There would be no change arising from the Modification to the following aspects of the approved Wilpinjong Coal Mine:

- open cut and contained infrastructure area;
- mine life;
- saleable coal transport off-site (12.5 Mtpa) or associated average or maximum rail movements; and
- operational workforce (up to approximately 550 people).

A comparison of the sequencing of extraction for Modification 5 and Modification 6 can be made by inspecting **Figure 3** (Modification 5) and **Figure 4** (Modification 6).

The proposed ROM production rate under Modification 6 is higher than the approved mine but the extent of the approved open cut would not be changed. There would also be no change to the final void configuration. Nor is there a change in the overall duration of the mine plan between the proposed and approved plans (both are scheduled for completion in 2026).

From a groundwater perspective, this means that there would not be any material change to the total volume of water withdrawn from the groundwater system, or the average impacts on

bore drawdowns, stream fluxes or takes from the alluvium associated with Wilpinjong Creek. There would, however, be some incidental changes to the timing of the effects on water levels and fluxes due to the differences in the mine sequence.

Because Modification 6 proposes a change in timing from the approved mine plan, rather than a change to mine footprint or extent, further groundwater modelling (similar to that in HydroSimulations, 2013) was not deemed necessary. A qualitative and semi-quantitative approach has been used for this assessment of Modification 6.

It is noted that the Modification 5 assessment (completed in 2013) assessed the period 2014 to 2026, and that potential impacts of variations to the mining sequence associated with Modification 6 on estimated groundwater inflows are likely to be more pronounced later in the mine life. Notwithstanding, consistent with the approach adopted for assessment of Modification 5, this assessment considers potential variations in predicted mine inflows from the next full calendar year (i.e. 2015).

Assessment of Effects of Modification 6

The assessment of the effects of Modification 6 requires:

- Evaluation of mine sequencing, and the differences between the approved mine and Modification 6.
- Evaluation of change to groundwater inflow hydrographs, on a pit-by-pit basis and as a total for the mine.
- Assessment of the shift in timing for potential effects on other aspects:
  - monitoring bore drawdowns;
  - creek flux changes;
  - Cumbo Creek excavation; and
  - loss of alluvial groundwater to the underlying rock.
- Assessment of adequacy of existing or previously quantified groundwater licence volumes for the Wilpinjong Coal Mine as described in HydroSimulations (2013).

Mine Sequencing

Further to the mine sequences provided in **Figure 3** and **Figure 4**, GIS analysis allowed calculation of the area, in square metres (m^2), of newly opened or newly excavated areas within each of the six defined pits. The newly opened area each year for each pit from 2015 onwards is presented in **Figure 5**. In each case, the solid line represents the indicative Modification 5 mining sequence and the dotted line represents the corresponding sequence for Modification 6.

The Modification 5 and Modification 6 mine sequences differ in the following key ways (**Figure 5**):

- Peak activity in Pits 1 and 2 would occur earlier in the Modification 6 mine life.
- Peak activity in Pits 3 and 4 would occur later in the Modification 6 mine life.
- Development of Pit 5 would be completed by 2019 under Modification 6 instead of 2024.
- Pit 6 would be mined more consistently for Modification 6.

Assessment of Groundwater Inflows to Pits

Based on the re-sequencing of mining, the inflow expected to each pit and in each year is also expected to change. As there would not be any material changes to the total volume of

water withdrawn from the groundwater system, the main task in this study was to recalculate the predicted annual inflows.

Previously predicted mine inflows for the approved mine (Modification 5) on a pit-by-pit basis and a total for the mine, are presented in Chart A on **Figure 6**. This data was taken directly from HydroSimulations (2013).

Figure 6 Chart A shows that Pit 5 and Pit 6 are predicted to be the main contributors to pit inflows during the life of the mine. Pit 5 and Pit 3 were predicted to contribute the most to the peak inflow year of 2015, with some contribution also coming from Pit 4.

Re-evaluation of the inflow hydrograph for each pit, to assess inflows under Modification 6, was done by:

- Using the predicted total inflow to each pit as the basis for this assessment. This has been used because the total area of extraction within each pit would not change;
- Assuming that inflows will generally be higher early on in the life of a pit than toward the end of the life of a pit. This is because early on during pit development the surrounding groundwater levels are still unaffected or less affected by mining, and higher groundwater levels result in steeper hydraulic gradients toward the open pit. Any subsequent mining causes a lowering of groundwater levels and depletion of groundwater storage in nearby areas and consequently inflows to the pit will decline over time; and
- Assuming a relationship between newly opened area and groundwater inflow[1].

The analysis was done by taking the GIS mine sequence data for both the approved mine and Modification 6 and calculating the area excavated in each year for each pit in ArcGIS. This data was then transposed into an MS Excel spreadsheet.

Charts B-G on **Figure 6** present the resultant inflows for each pit under the Modification 6 mine sequence compared against modelled inflow hydrographs for the approved mine (i.e. Modification 5). Chart H on **Figure 6** presents a comparison of the total inflow for all pits.

Figure 6 shows the following:

- Pits 1 and 2 (Charts B and C) were not predicted to receive any groundwater inflow, i.e. are 'dry' workings (HydroSimulations, 2013). This situation is predicted to remain unchanged under Modification 6.
- Inflows to Pit 3 are presented on Chart D. Under Modification 6 there are predicted to be slightly lower inflows until 2017, followed by a higher peak inflow (750 megalitres per annum [ML/a] in 2018). Following that there are predicted to be lower inflows.
- Higher inflows are predicted at Pit 4 (Chart E) from 2014-2017, then declining to very low inflows until 2023. In 2024 inflows are predicted to peak at about the same rate.
- Under Modification 6 Pit 5 inflows (Chart F) are predicted to be down slightly in 2015. After 2016 inflows are predicted to be slightly higher, before falling to low rates of inflow after 2019.
- Under Modification 6 inflows to Pit 6 (Chart G) are predicted to peak earlier (in 2021), declining consistently from there until 2026.

[1] An alternative method would be to assume that inflow is related to newly opened perimeter. HydroSimulations have used both area and perimeter methods in previous studies, e.g. HydroSimulations, 2014 and Heritage Computing, 2012.

- Chart H presents the predicted total inflow to the mine. This graph shows that predicted inflows in the early period of the Modification 6 mine sequence remain very similar. Peak inflow is still predicted to occur in 2015, although it is predicted to be marginally lower. After 2017 inflows are predicted to be slightly higher, and in 2021 total inflows are predicted to reach 1650 ML/a as the peak inflow associated with Pit 6 is expected to occur earlier. After that time inflows are predicted to decline and generally be less under Modification 6.

A summary of the predicted total annual groundwater inflow to the mine is presented in Table 1. The annual average and maximum inflow are reported on the last two lines of the table.

Table 1 Summary of Predicted Total Annual Groundwater Inflow [ML/a]

YEAR	MODIFICATION 5	MODIFICATION 6
2014	1775	1775
2015	2038	1979
2016	1862	1598
2017	1064	729
2018	908	1067
2019	266	340
2020	24	150
2021	626	1647
2022	797	964
2023	963	1025
2024	1519	824
2025	815	477
2026	0	82
Total	12657	12657
Average	974	974
Maximum	2038	1979

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The maximum inflow is the volume or 'groundwater take' for which a groundwater licence must be sought. Under the approved mine the peak 'take' was predicted to be 2038 ML/a. Under Modification 6 it is predicted that there would be a marginal decline, of less than 3%, to 1979 ML/a in the peak annual 'take' at the Wilpinjong Coal Mine.

A breakdown of inflows to each pit under Modification 6, from 2015 onwards, is presented in Table 2, including the predicted maximum annual inflow (for the remainder of the mine life) to each pit.

Table 2 Predicted Groundwater Inflow (ML/a) to Each Pit under Modification 6

YEAR	PIT 1	PIT 2	PIT 3	PIT 4	PIT 5	PIT 6
2015	0	0	681	673	626	0
2016	0	0	282	613	702	0
2017	0	0	216	163	351	0
2018	0	0	750	0	317	0
2019	0	0	275	0	65	0
2020	0	0	147	0	2	0
2021	0	0	169	0	0	1478
2022	0	0	91	0	0	873
2023	0	0	25	256	0	744
2024	0	0	0	353	0	471
2025	0	0	32	0	0	444
2026	0	0	0	0	0	82
Average	0	0	267	412	344	682
Average (ML/d)	0.00	0.00	0.83	1.06	1.33	1.87
Maximum (ML/a)	**0**	**0**	**750**	**673**	**702**	**1478**

Averages based on periods of non-zero inflow during 2015-2026 inclusive.

Effects on Cumbo Creek and Wilpinjong Creek

Impacts on Cumbo Creek would be manifested as baseflow capture due to drawdown from surrounding mine workings and also through removal of alluvium.

Alluvium Extraction

As with groundwater inflows, the total amount of alluvium, as mapped on the Dubbo 1:250,000 geology mapsheet (Colquhoun *et al*., 1999), extracted under Modification 6 would be the same as under the approved mine plan. Only the timing would differ.

No alluvium is mapped in Pits 1, 2, 5 and 6 (**Figure 2**). Alluvium is mapped as being present on the western edge of Pit 3 along Cumbo Creek and at the confluence of Cumbo Creek and Wilpinjong Creek north of Pit 3 (**Figure 2**). Alluvium is mapped along the eastern portion of Pit 4, along Cumbo Creek, while the northern edge of Pit 4 extends into the alluvium mapped along Wilpinjong Creek (**Figure 2**). It is noted that the extent of alluvium mapped on the Dubbo 1:250,000 geology mapsheet is likely to be conservative based on recent geophysical surveys.

Under Modification 6 minor differences are predicted to be as follows, using the mine sequences presented in **Figures 3 and 4**Figure as a guide:

- In Pit 3 the mine sequence would see removal of mapped alluvium through 2015-2019. This would mean similar or slightly earlier removal of mapped alluvium to the east of Cumbo Creek, but slightly later timing for the area of mapped Wilpinjong Creek alluvium.
- In Pit 4 the mine sequence would see later removal of the Cumbo Creek alluvium from 2017 to 2023-24. Most of the Wilpinjong Creek alluvium within Pit 4 would be removed at a similar time except for one area which would be brought forward from 2024 to 2017.

Loss of Alluvial Groundwater to Underlying Rock

The overall fluxes between alluvium and underlying Triassic or Permian rock would be the same under Modification 6, however the timing would be different.

Around the Cumbo Creek alluvium, under the Modification 6 mine plan the difference is likely to manifest itself as:

- Slightly later downward flux from alluvium to rock in the early stages of the mine plan due to the proposed scheduling of Pit 4 extraction in areas near to Cumbo Creek. Furthermore there would be about 6-7 years later extraction of the alluvium immediately under Cumbo Creek.
- Increased downward flux toward workings in Pit 3 as areas immediately to the east of Cumbo Creek are extracted earlier.
- Overall, a very small change in the vertical flux from Cumbo Creek alluvium due to these two changes going some way to balancing one another out.

For the Wilpinjong Creek alluvium any changes in vertical flux between the alluvium and the underlying rock are predicted to be very minor. Pits 1 and 2 have already been mined out near the creek, and the timing of extraction of areas near to the creek in Pits 5 and 6 is very similar under the Modification 6 mine sequence.

Baseflow Capture

Average baseflow reduction to Cumbo Creek would be the same under Modification 6, however the timing would be different.

Under Modification 6 the difference in baseflow capture is likely to manifest itself as:

- Slightly later baseflow capture due to the proposed scheduling of Pit 4 extraction in areas near to Cumbo Creek, as well as about 6-7 years later extraction of the area immediately under the course of Cumbo Creek (and the alluvium).
- Increased baseflow capture by workings in Pit 3 as areas immediately to the east of Cumbo Creek are extracted earlier.
- An overall change in the baseflow capture that is likely to be very small due to these two changes going some way to balancing one another out.

On Wilpinjong Creek, the scheduling of extraction within Pits 5 and 6 means that there might be some delay in baseflow capture as areas near to the creek are scheduled to be mined out 1-3 years later, but any changes would be minor.

Groundwater Drawdown

Because the overall mine footprints for the approved mine and the proposed Modification 6 mine plan are the same, peak drawdown at any point around the mine is predicted to be the same. That is, imperceptible or no additional drawdown is likely to occur, and only the timing of peaks would differ based on the mine sequence.

CONCLUSION

Due to the same extent of mining for the approved mine and proposed Modification 6, a semi-quantitative assessment is sufficient to understand potential groundwater effects. This assessment is based on the differences between the sequencing of extraction between Modification 5 and Modification 6, and how that sequencing could affect the timing of inflows as previously predicted for the approved mine.

A relationship between newly opened area and mine inflow was constructed for each of the six pits for the approved mine, and used to re-calculate the inflow hydrograph for each pit under Modification 6. The results of this assessment are summarised below.

Based on the re-calculated inflows, peak annual 'groundwater take' at the Wilpinjong Coal Mine is not predicted to increase under Modification 6. The previously assessed licence volume (HydroSimulations, 2013) therefore remains adequate to cover the predicted peak inflow rate (as required by NOW).

Modification 6 would have no discernible impact on stream baseflows, beyond the effects of approved mining. Only the timing of any baseflow capture would change.

Modification 6 would have no discernible impact on groundwater upflow from the Permian sediments to overlying alluvium, beyond the effects of approved mining.

Modification 6 would have no discernible additional drawdown at any of the alluvium or coal bores in the monitoring network. Only the timing of any drawdown would change.

Modification 6 would not contribute to any measurable incremental cumulative effect (including the effects of the proposed Moolarben Coal Project Stage 2).

Modification 6 could not be considered to have a significant impact on the recovery of groundwater levels, beyond the effects of approved mining.

Modification 6 could not be considered to have a significant impact on groundwater quality, beyond the effects of approved mining.

The AI Policy establishes minimal impact considerations for 'Highly Productive' and 'Less Productive' groundwater. Alluvium classified as 'Highly Productive' groundwater, exists to the north-east of the Wilpinjong Coal Mine along Wilpinjong Creek and to the east along Wollar Creek. Other groundwater sources are 'Less Productive'.

An assessment against the minimal impact considerations in the AI Policy was conducted by HydroSimulations (2013). The assessment concluded that Modification 5 was within the 'Level 1' minimal impact considerations outlined in the AI Policy.

Based on the assessment findings documented above, Modification 6 would also be within the 'Level 1' minimal impact considerations outlined in the AI Policy as impacts would largely be unchanged.

Yours sincerely

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REFERENCES

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ATTACHMENTS

Document:

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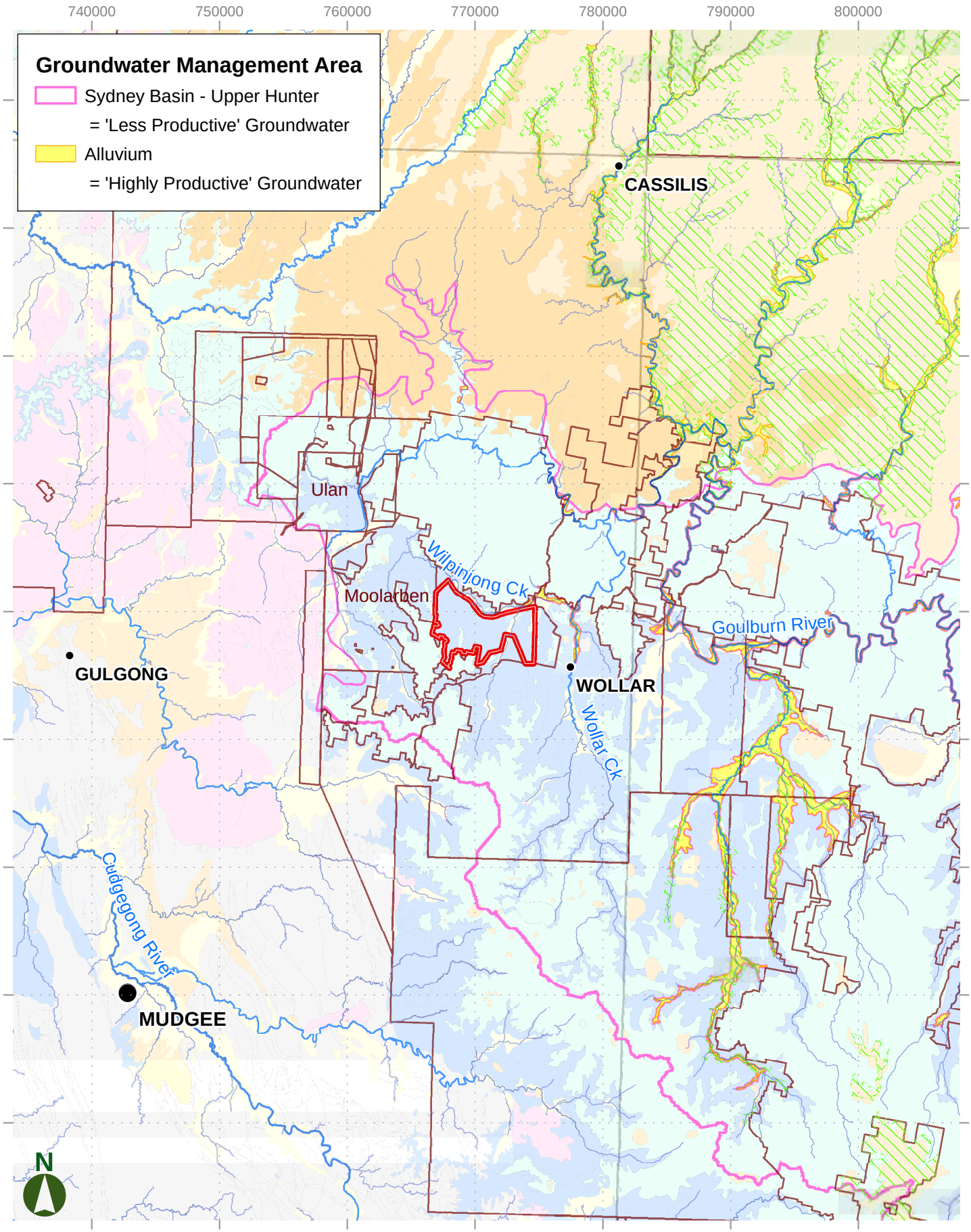

Biophysical Strategic Agricultural Land (BSAL)
ML1573 (Wilpinjong)
NSW coal title

Geology outcrop (250k)

other
Quaternary
Tertiary
Jurassic
Triassic
Permian
Carboniferous

Scale: 400,000 at A4
GDA 1994 MGA Zone 55

0 2 4 8 12 16 kilometres

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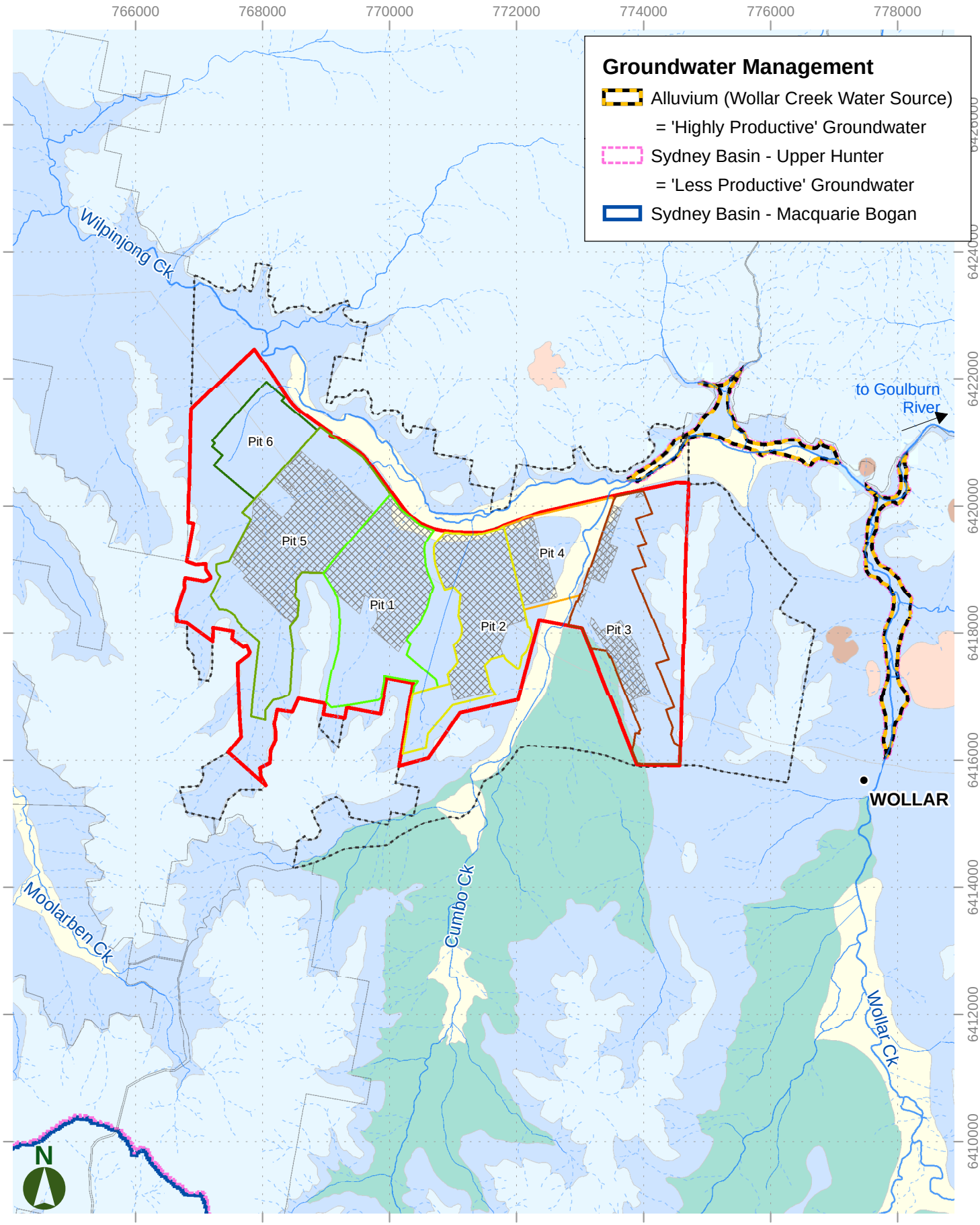
HydroSimulations

Wilpinjong Coal
Assessment of Modification 6

Figure 1
Project Location



Wilpinjong Mine

- Pit 6
- Pit 5
- Pit 1
- Pit 2
- Pit 4
- Pit 3
- mined (at Dec 2014)

- NSW coal title

Geology outcrop (250k)

- Alluvium
- Tertiary basalt
- Mesozoic igneous
- Triassic Narrabeen Group
- Permian Illawarra Coal Measures
- Permian Shoalhaven Group

Scale: 80,000 at A4
GDA 1994 MGA Zone 55

0 0.5 1 2 3 4 kilometres

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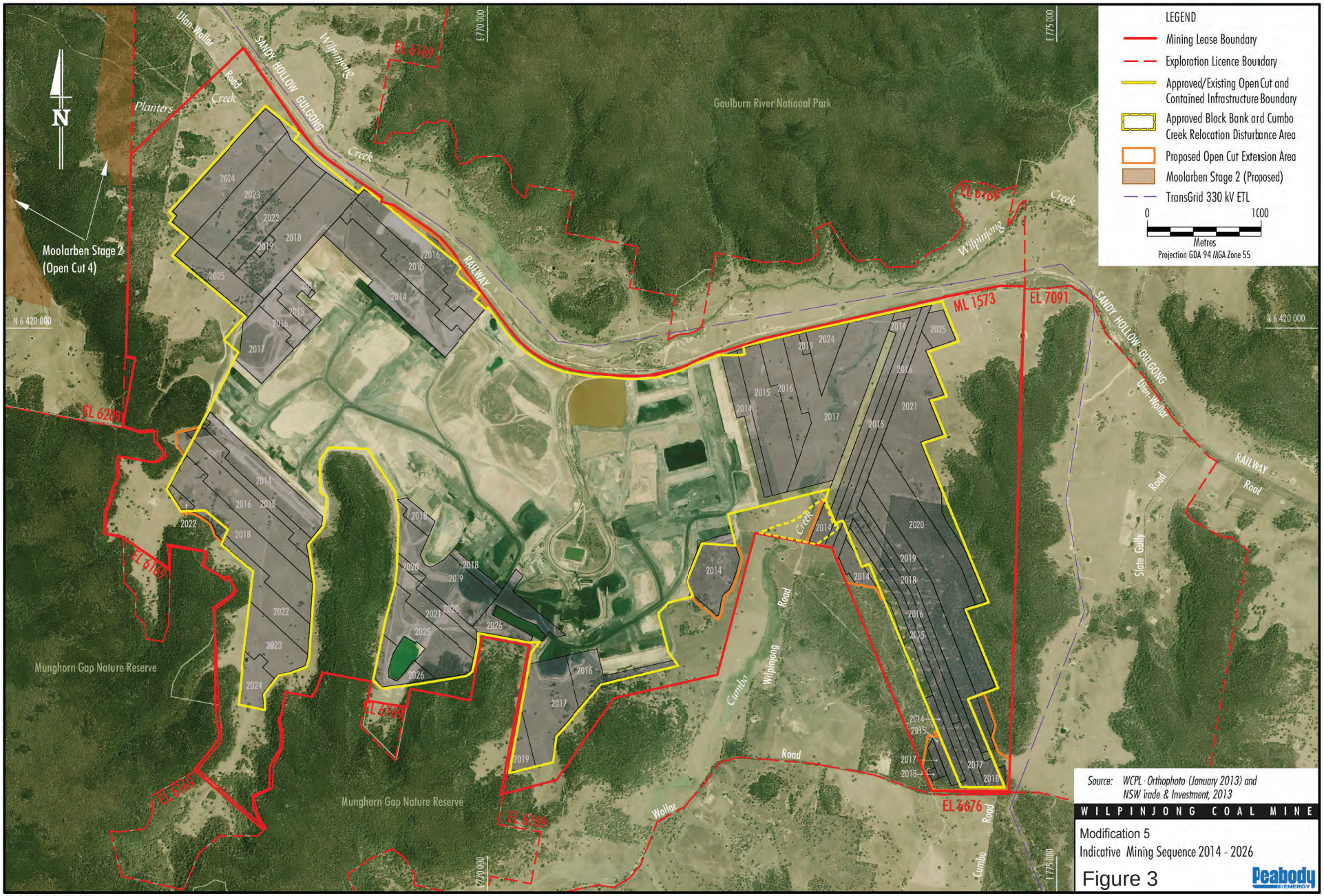
Wilpinjong Coal
Assessment of Modification 6

Figure 2
Mine Layout



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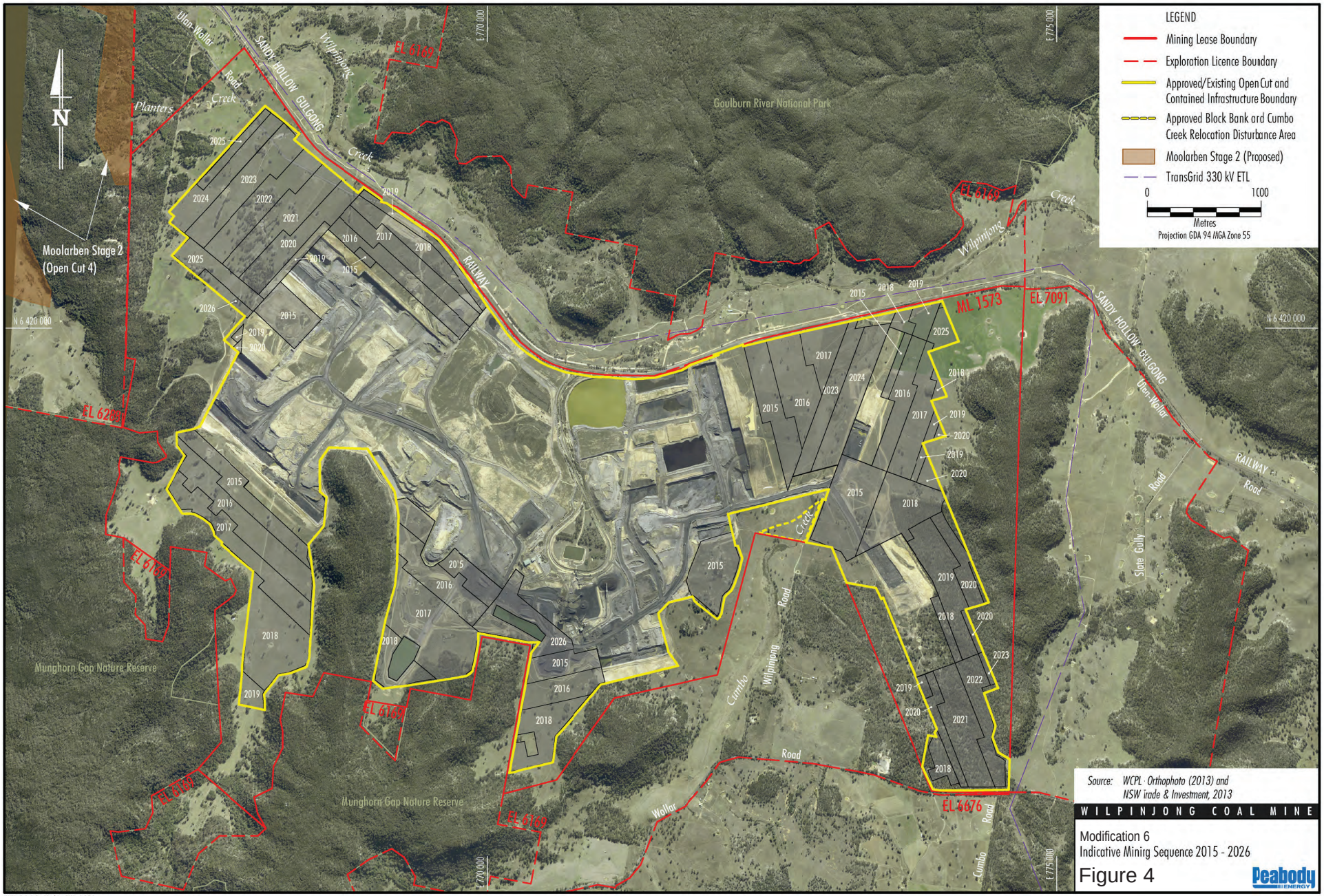

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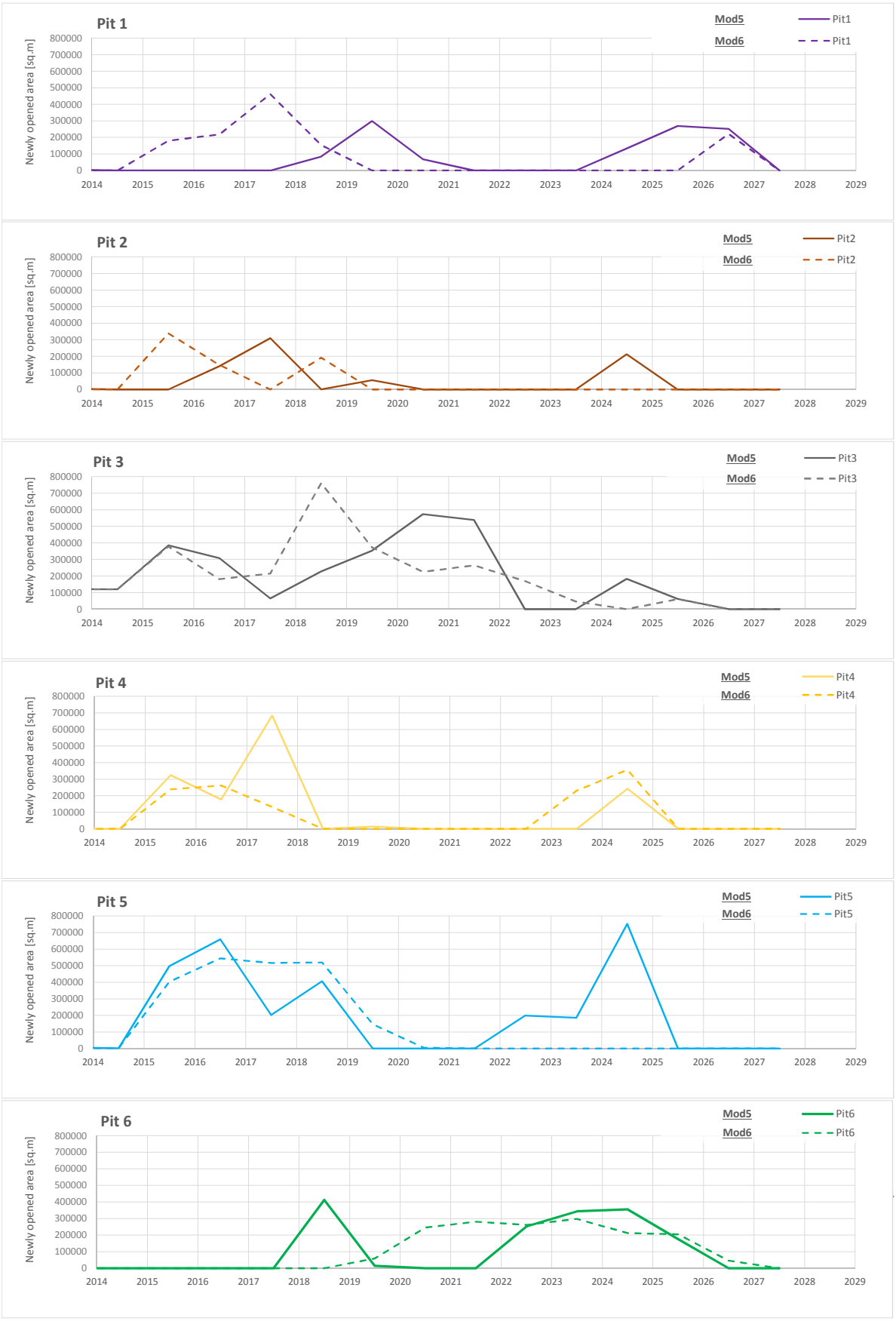

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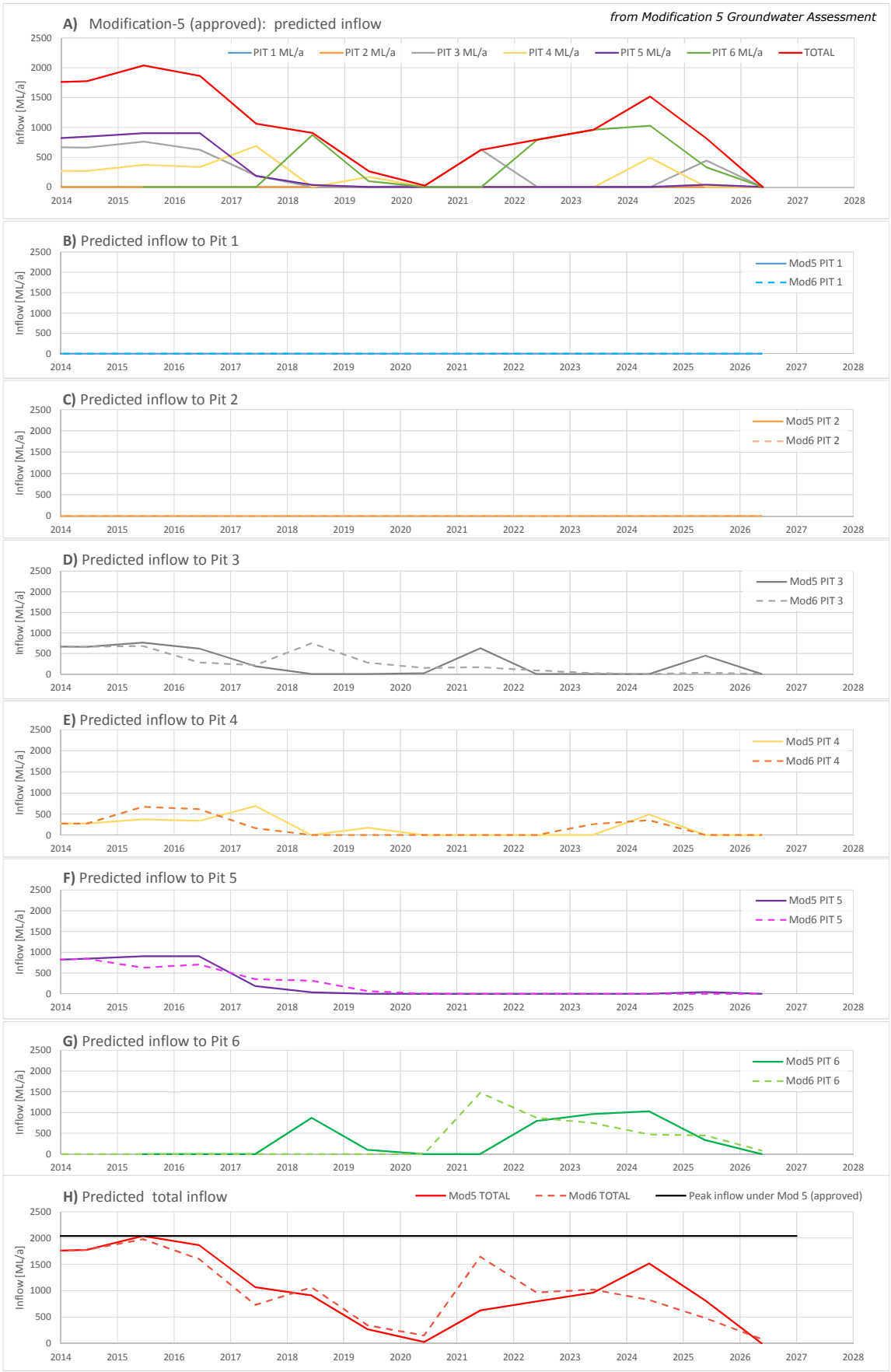
Comparison of Newly Opened Area under Modification 5 and Modification 6 **Figure 5**



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Predicted Mine Inflows under Modification 5 and Modification 6 **Figure 6**