Memorandum

To:	Stephen Love	At:	Metropolitan Collieries Pty Ltd
From:	Dr. Noel Merrick	At:	SLR Consulting Australia Pty Ltd
Date:	28 September 2020	Ref:	665.10000-M03-v2.0.docx
Subject:	Metropolitan Coal Groundwater Investigation into water level changes at bore T3 and T5		

1 Introduction

On 11 August 2020, Metropolitan Collieries Pty Ltd (Metropolitan Coal) requested that SLR Consulting Australia Pty Ltd (SLR) undertake an investigation into an exceedance of the Level 3 groundwater trigger level measured at piezometer T3. During the time of the investigation, an exceedance of the Level 3 groundwater trigger level associated with piezometer T5 also occurred. The investigation below provides an assessment of both events against the relevant performance measures in Project Approval 08_0149 and provides recommendations in relation to the groundwater trigger events.

2 Background

Groundwater monitoring results at the Metropolitan Mine are assessed against performance indicators using the Trigger Action Response Plan (Table 25) detailed in the Longwalls 305-307 Water Management Plan (Revision WMP-R01-B approved 16 March 2020).

The performance indicator for Bore T3 is:

> "The hydraulic gradient to the Woronora Reservoir from bore T3 is reduced by no more than 10% from that measured on 30 June 2017."

The performance indicator associated with Bore T5 is:

> "The hydraulic gradient from bore T5 to bore T3 is reduced by no more than 10% from that measured on 30 June 2017."

2.1 Bore T3 Details

At 30 June 2017, the water level in the Woronora Reservoir (WRL) was 168.90 mAHD and the T3 water level was 173.32 m AHD, giving a baseline difference of:

> T3 – WRL = 4.42 m

An exceedance of the Level 3 trigger performance indicator would occur for the following condition:

> T3 – WRL =< 3.98 m

where WRL is the dynamic Woronora Reservoir Level.

Bore T3 has the following key survey details:

- Hole depth 61 m
- Collar level 225.45 mAHD
- Diver sensor level 166.435 mAHD
- Bottom of hole 164.45 mAHD

2.2 Bore T5 Details

At 30 June 2017, the water levels in Bores T5 and T3 were 191.24 mAHD and 173.32 m AHD, respectively, giving a baseline head difference of:

T5 – T3 = 17.92 m

An exceedance of the Level 3 trigger performance indicator would occur for the following condition:

T5 – T3 =< 16.13 m

Bore T5 has the following key survey details:

- Hole depth 94 m
- Collar level 258.04 mAHD
- Diver sensor level 166.104 mAHD
- Bottom of hole 164.04 mAHD

2.3 Exceedance Events

An exceedance was first identified for bore T3 on 29 July 2020, as shown in Figure 1. The exceedance has continued through to 31 August 2020, the last date considered in this assessment. The sharp change in the gradient is caused by both a decrease in water level at T3 and an increase in water level in the Woronora Reservoir at the same time, both processes decreasing the difference between the two water levels.

In Figure 1, the WRL is represented by the water level measured at Bore T1 (about 20 m from the edge of the reservoir), as this best represents the reservoir level above an old weir that has been exposed during a recent period of very low reservoir water levels (Figure 2). Figure 2 also shows the locations of transect bores T1 to T5 on the eastern side of the reservoir. Another bore (T6) is located on the western side.

The weir pool provides the most appropriate water level for assessment of the hydraulic gradient from Bore T3 to the reservoir. The maximum weir pool level, measured manually by Metropolitan Coal, is about 160.1 mAHD. The main reservoir water level dropped below this level from 23 August 2018 to 12 February 2020, and reached a minimum level of 150.76 mAHD on 6 February 2020. During that period, the T1 level was consistently about 0.5 m lower than the weir pool level, as T1 is controlled not only by the weir pool but also by 3-dimensional regional groundwater levels influenced by the main reservoir. For normal higher reservoir levels, the groundwater level at T1 is 0.08 m higher than the published WaterNSW reservoir level, on average.

An exceedance was first identified for the (T5-T3) trigger on 19 August 2020, as shown in Figure 3. The exceedance occurred for nine of the 13 days through to 31 August 2020, the last date considered in this assessment. The minimum level of 16.00 m, 13 cm below the threshold, was measured on 31 August 2020. The lowering of the head difference to the Level 3 threshold is caused by a mild decrease in water level at T5 while T3 remains fairly stable, as shown in Figure 3.

3 Performance Measure Assessment

In accordance with the Trigger Action Response Plan, an investigation has been conducted and an assessment has been made against the following performance measure:

> Negligible leakage from the Woronora Reservoir.

Several performance indicators involving bores T2, T3 and T5 are designed to provide an early warning for assessment of potential exceedances of this performance measure.

Leakage from the Woronora Reservoir to the surrounding groundwater environment would occur if there is a reversal of hydraulic gradient (i.e. if the water table in surrounding piezometers falls below the water level in the Woronora Reservoir).

3.1 Bore T3 Assessment

During the period of exceedance (from 29 July 2020 through to 31 August 2020), the water level at T3 remained approximately 6 m above the reservoir level after it had recovered above the level of the old weir on 13 February 2020, and the head difference reduced to a minimum of 1.82 m on 25-26 August 2020 following another substantial rise in reservoir level due to 183 mm of rain during 27-29 July 2020 (Figure 1). As the reported water level is at the level of the sensor, about 2 m above the bottom of the hole, the actual water level could be lower than reported and could be similar to the current reservoir level. However, there has not been a reversal of gradient from T3 to the Woronora Reservoir (either upstream or downstream of the old weir) that would induce leakage from the reservoir because the intervening bore T2 still shows an hydraulic gradient towards the reservoir (Figure 4), and its water level increased following the heavy rainfall event in late July 2020.

Water level behaviour at bores T2 and T3 is shown in Figure 4 where hydrographs for each of the transect bores are compared. Only Bore T6 has a strong correlation with rainfall, indicated by the similarity of its variations in water level with rainfall residual mass.

Bores T2 and T3 behave similarly, initially responding to the decline in reservoir level and then, from late 2018, remaining fairly steady in line with bore T1 and the weir pool. Bore T3, however, shows a slight rise with time during all of 2019, with an increased gradient from February 2020 to 29 April 2020 (coincident with the rise in reservoir level), after which the water level dropped suddenly to the level of the sensor at 166.5 mAHD. This occurred 17 days after the commencement of Longwall 305 on 12 April 2020. Bores T2 and T4 show small but muted responses at a similar time, whereas bore T5 shows a large 13 m increase in head when Longwall 305 passed beneath this bore. Similar but smaller rises in water level at bore T5 since early 2019 are assessed separately below, as they provide some insight into mechanisms that might be contributing to the disturbance observed at bore T3.

Bore T3 is located over the centre of Longwall 306 (yet to be mined) at distances of about 50 m from the nearest gate road and about 130 m from the western edge of Longwall 305 (Figure 5). The gate road was driven in February 2020 about the time the T3 water level increased its rate of rise. The mining face for Longwall 305 would have passed the northing of bore T3 around 11 May 2020 when the water level at bore T3 had dropped to 168.9 mAHD.

Figure 6 shows the mining progression at the time of the T3 disturbance from February 2020, when a slow rise in water level commenced, to May 2020 at the end of the sharp drop in water level at bore T3. The rising water level is probably due to compressive effects caused by the nearby development heading, as no longwall extraction occurred in February or March 2020, and no corresponding rise is observed at bore T2 when the reservoir water level rose in February 2020. The peak water level was registered when the Longwall 305 mining face was about 220 m from bore T3 along a line with bearing 040. The sharp drop in water level is due to depressurisation associated with development of a fractured zone into the Bulgo Sandstone above the mined Bulli Seam.

Figure 7 shows a west-to-east geological section through VWP bore 9EGW2-4 and the transect bores T1-T5, showing in particular the position of bore T3 relative to longwall mining. The imaginary line from the sensor at bore T3 to the western edge of Longwall 305 forms a real angle of about 18 degrees from the vertical. As this is well within the angle of draw of 35 degrees, as adopted by Metropolitan Coal, it is not surprising that depressurisation would occur at bore T3 due to Longwall 305 mining.

When the mining face of Longwall 304 passed the northing of bore T3 in August 2019, there was no significant effect at bore T3 other than a slight rising trend in water level. At this time the angle between the T3 sensor and the goaf would have been about 42 degrees, greater than the adopted angle of draw. Depressurisation would not have been expected at this time, but slight compressive effects are plausible.

There is an observed mild mining effect at bore T2 in May-June 2020. At this time the angle between the T2 sensor and the Longwall 305 goaf would have been about 31 degrees, very similar to the adopted angle of draw. Consequently, some mining effect is plausible.

It is to be expected that the water level at T3 should rise gradually in response to rising reservoir level, as has happened at T1 and T2. However, when Longwall 306 commences, an initial rise in water level from compressive effects is likely, followed by more substantial depressurisation than has been observed to date. A Level 3 performance indicator is likely to pertain until the completion of Longwall 306.

3.2 Bore T5 Assessment

Bore T5 is located near the centre of Longwall 305 at distances of about 30 m from the nearest gate road to the west and about 75 m from the northern commencing edge of Longwall 305 (Figure 5). The position of bore T5 relative to longwall mining is shown on the west-to-east geological section in Figure 7 and also on a south-to-north geological section through VWP bores 302GW01, F6GW4A and PHGW2A (Figure 8).

Water level behaviour at bore T5 is shown in Figure 4, compared with other transect bores, and in Figure 9 where hydrographs for neighbouring VWP sensors (at a similar elevation to the T5 sensor) are compared.

The most striking feature of the T5 hydrograph is a succession of three broad episodic water level rises increasing in amplitude with time, punctuated by a spike event in January 2020. As each of the three broad events occurs shortly after commencement of Longwalls 303, 304 and 305, and the amplitude increases with the proximity of bore T5 to the active mining face, it is probable that mining is causing a redistribution of the natural stress field and that bore T5 is the recipient of compressive effects.

Bore T5 is not unique in registering compressive effects, as similar effects have been observed at bore 302GW01 and F6GW4A (Figure 9) at similar elevations to the T5 sensor elevation. Bore 302GW01 is a goaf hole situated over the centre of Longwall 302 at about one-third of the distance along Longwall 302 from its northern commencing end. There is evidence in Figure 9 of a compressive water level high in late-2017 due to the mining of Longwall 301 at least 200 m distant, followed by sharp compression in May 2018 immediately preceding sudden depressurisation by about 45 m. Bore F6GW4A is located over the chain pillars separating Longwalls 303 and 304, along the same normal to the panels as 302GW01. The hydrograph for this bore also shows three broad compressive episodes of slightly greater progressive amplitudes to those observed at bore T5. Each water level rise peaks at a similar time after commencement of the corresponding longwall panels 301, 302 and 303. Depressurisation of about 35 m occurred suddenly in February 2019 when the Longwall 303 mining face had gone about 150 m past the bore. Water levels have recovered partially since that time, but not monotonically, and remain about 5 m lower than pre-mining levels.

Figure 10 shows the mining progression at the time of the first T5 disturbance from December 2018 to March 2019, characterised by a sharp rise in water level followed by a slow decline. The first effect occurred when T5 was about 500 m from the Longwall 303 mining face (moving north to south) and about 530 m from development headings (moving south to north). At this time the angle between the T5 sensor and the goaf would have been about 51 degrees, greater than the adopted angle of draw. Depressurisation would not have been expected at this time, but slight compressive effects are plausible.

Figure 11 shows the mining progression at the time of the second T5 disturbance from August to October 2018, characterised by equally sharp rise and fall in water level. The first effect occurred when T5 was about 175 m from the Longwall 304 mining face (moving north to south) and very distant from the development headings (moving south to north). At this time the angle between the T5 sensor and the goaf would have been about 24 degrees, within the adopted angle of draw. Some depressurisation would have been expected at this time following a compressive event, and this has been observed. About 3 m lowering of water level below prior conditions was observed in December 2019 and January 2020.

The uncharacteristic spike in the T5 hydrograph occurred in January 2020 when no longwall mining was active, as shown in Figure 12. However, development headings (moving south to north) had approached within 150 m of bore T5 by the time the spike had subsided. As no similar spike event has been observed at any other site, the explanation for the spike remains obscure. It might be due to a sudden collapse of rocks into the goaf or a rearrangement of blocks of rock in the fractured zone, but it is not due to progressive movement of a mining face.

The mining progression at the time of the third broad T5 disturbance from April to June 2020 is shown in Figure 13. The water level in this bore started rising immediately upon commencement of Longwall 305 and peaked when the mining face was about 250 m past the bore (compared with 150 m in the case of F6GW4A). As the bore was directly undermined, depressurisation is expected and has been observed to be about 13 m below prior conditions at the end of August 2020 (compared with 45 m at 302GW01 and 35 m at F6GW4A for direct undermining).

The slow decline in the T5 water level, coupled with a steady level at T3, has caused the (T5-T3) head difference to reduce slowly towards and across the Level 3 threshold for the gradient from T5 to T3, as shown in Figure 3. From the behaviour observed at F6GW4A following undermining, it is to be expected that the water level at T5 should rise gradually over the next 6-9 months, thereby increasing the (T5-T3) head difference and restoring the performance indicator to Level 2 or Level 1.

4 Conclusion and Recommendations

In accordance with the Trigger Action Response Plan, investigations have been conducted into observed exceedances of the Level 3 groundwater trigger levels associated with bores T3 and T5 in the form of the gradient from T3 to the reservoir, and the gradient from bore T5 to bore T3. The exceedance of the first trigger has persisted for a full month from 29 July 2020 to 31 August 2020, the end date for this investigation. The exceedance of the second trigger is quite recent, having occurred for only nine days during August 2020.

It is to be expected that the water level at T3 should rise gradually in response to rising reservoir level, as has happened at T1 and T2. However, when Longwall 306 commences, an initial rise in water level from compressive effects is likely, followed by more substantial depressurisation than has been observed to date. A Level 3 performance indicator is likely to pertain until the completion of Longwall 306.

Although an exceedance has occurred for the gradient between bore T3 and the reservoir, there has not been a reversal of gradient from T3 to the Woronora Reservoir that would induce leakage from the reservoir (the performance measure) because the intervening bore T2 still shows an hydraulic gradient towards the reservoir (Figure 4), and its water level increased following the heavy rainfall event in late July 2020. The depressurisation at bore T3 is localised.

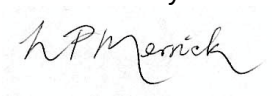
The slow decline in the bore T5 water level, coupled with a steady level at bore T3, has caused the (T5-T3) head difference to reduce slowly towards and across the Level 3 threshold for the gradient from T5 to T3, as shown in Figure 3. From the behaviour observed at F6GW4A following undermining, it is to be expected that the water level at T5 should rise gradually over the next 6-9 months, thereby increasing the (T5-T3) head difference and restoring the performance indicator to Level 2 or Level 1.

The Longwalls 305-307 Water Management Plan requires Metropolitan Coal to consider the need for management measures following the exceedance of a performance indicator.

- Performance indicator (T3-WRL): As the reported water level at bore T3 is at the level of the sensor, about 2 m above the bottom of the hole, the actual water level could be lower than reported and could be similar to the current reservoir level. It is recommended that a manual measurement be made at bore T3 to determine whether the actual water level is lower than the sensor level, and whether the bore still holds water or is dry. The bottom elevation of bore T3 was designed to be about 5 m below the full storage level of the reservoir. If the bore is dry, consideration could be given to extending the depth of the hole.
- Performance indicator (T5-T3): No specific management measure is considered to be required, other than ongoing monitoring and a check on performance each month.

It is also recommended that, in the next revision of the Longwalls 305-307 Water Management Plan, the reference level for the reservoir be clarified, given the control exerted by an obsolete weir when main reservoir levels are very low. It is recommended that the water level at bore T1 be endorsed as a surrogate reservoir level, as the data at T1 are collected at the same frequency as measurements at bore T3, and the levels at bore T1 automatically take into account the effect of the obsolete weir.

Yours sincerely



Noel Merrick

0424 183 495

Checked/
Authorised by: IE

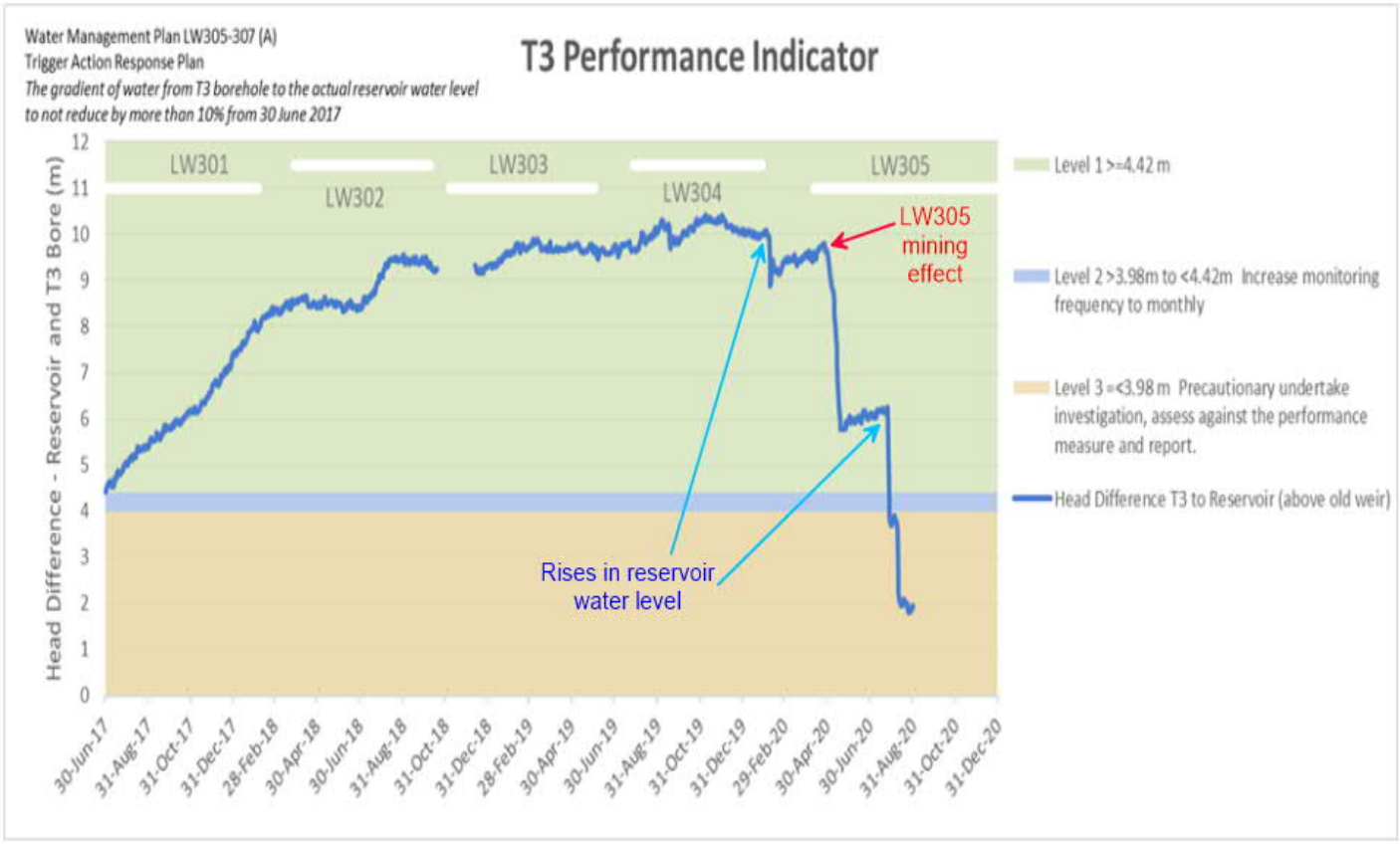


Figure 1 Bore T3 performance indicator

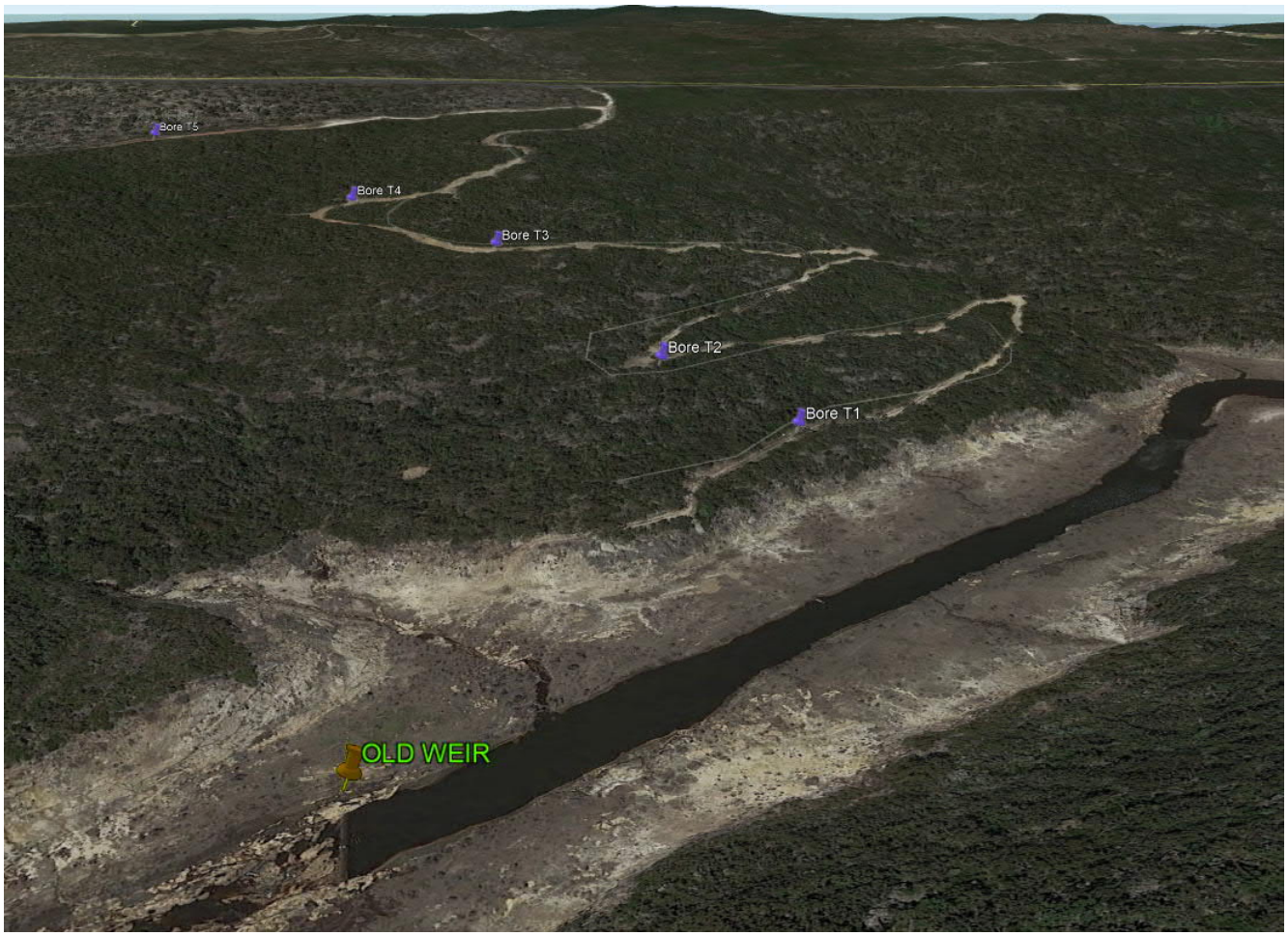


Figure 2 Google Earth view looking east showing the old weir and Bores T1 to T5

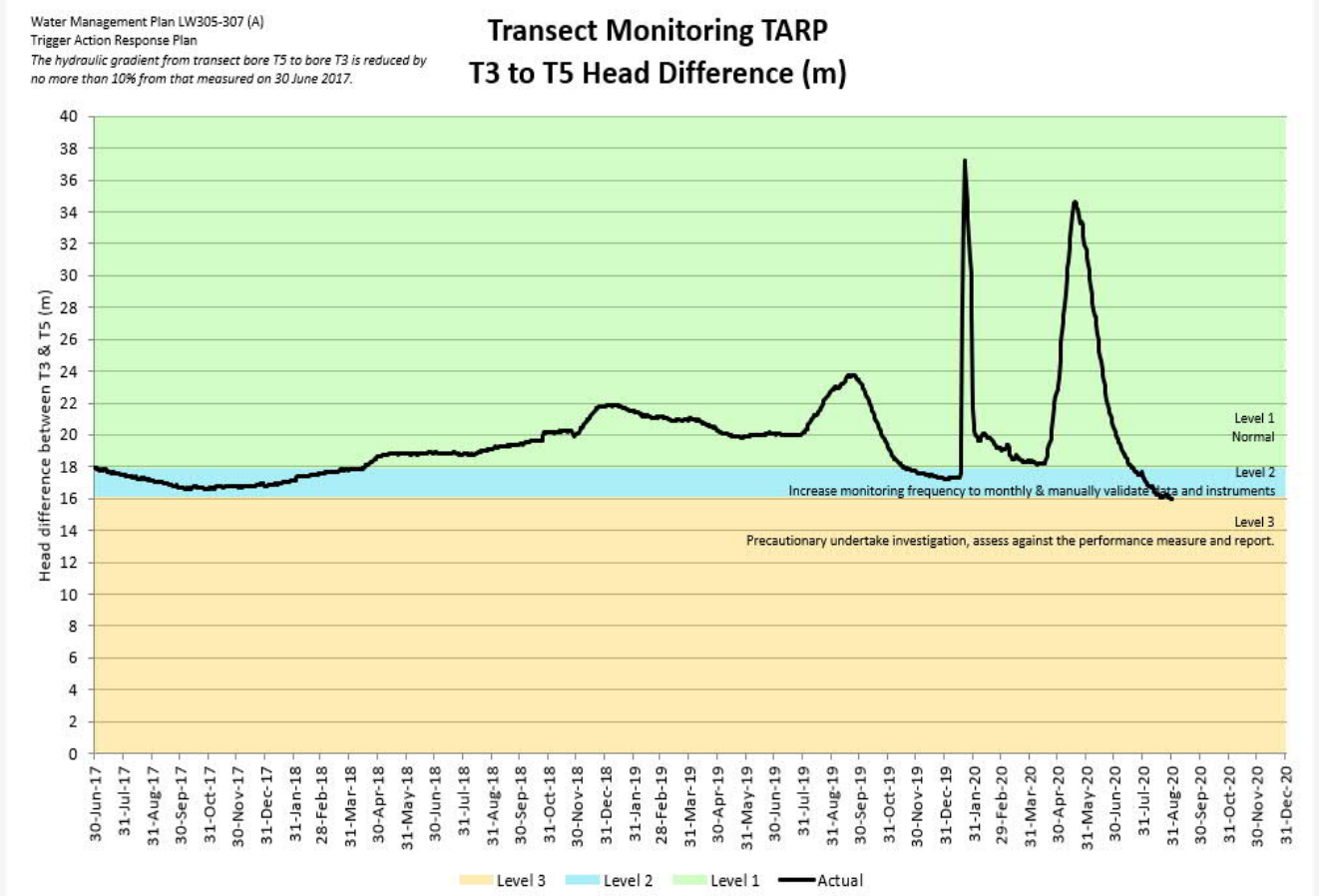


Figure 3 Performance indicator for Bores T3 and T5

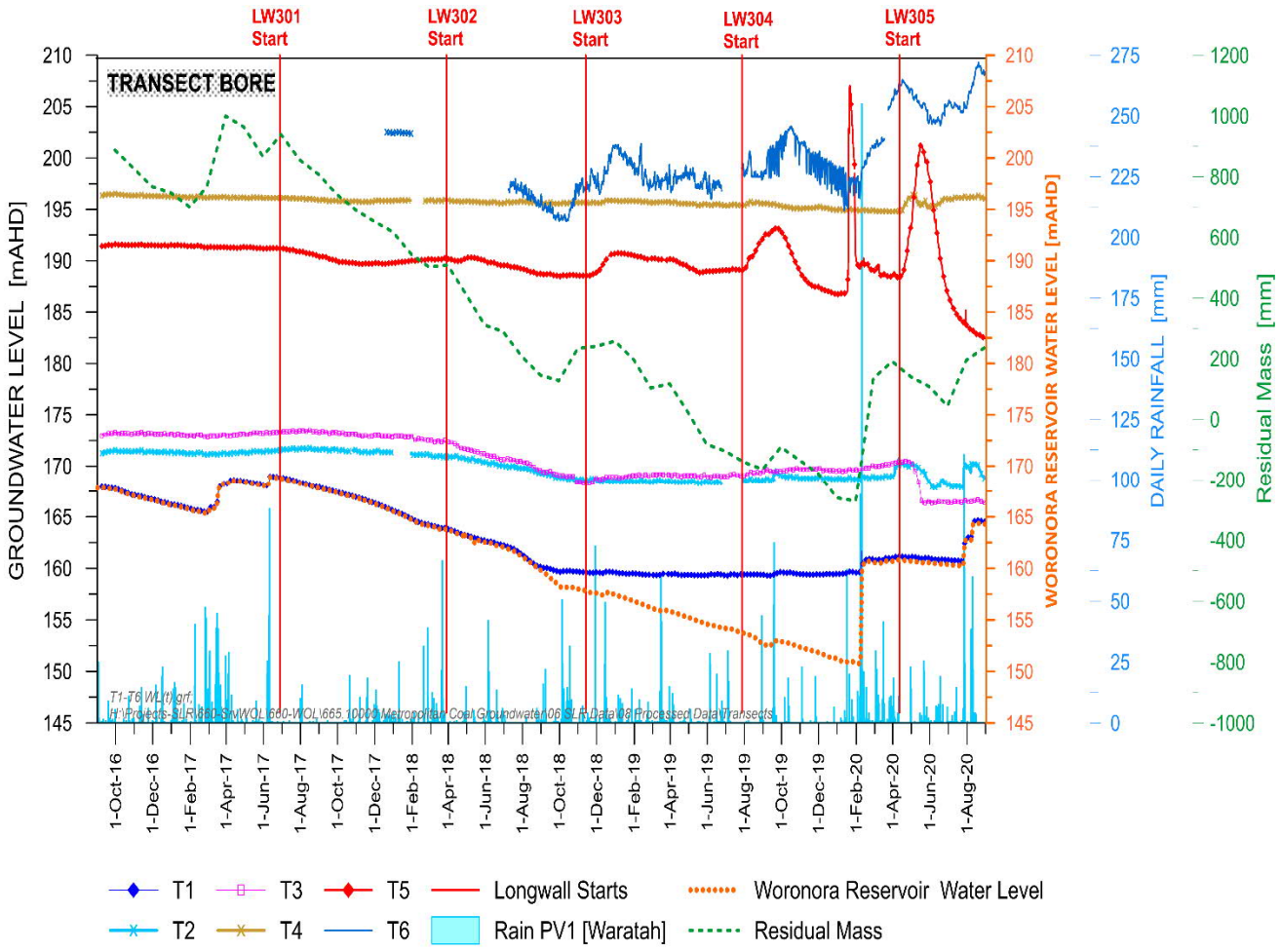


Figure 4 Groundwater hydrographs for bores T1 to T6 compared with reservoir water level, rainfall and rainfall residual mass

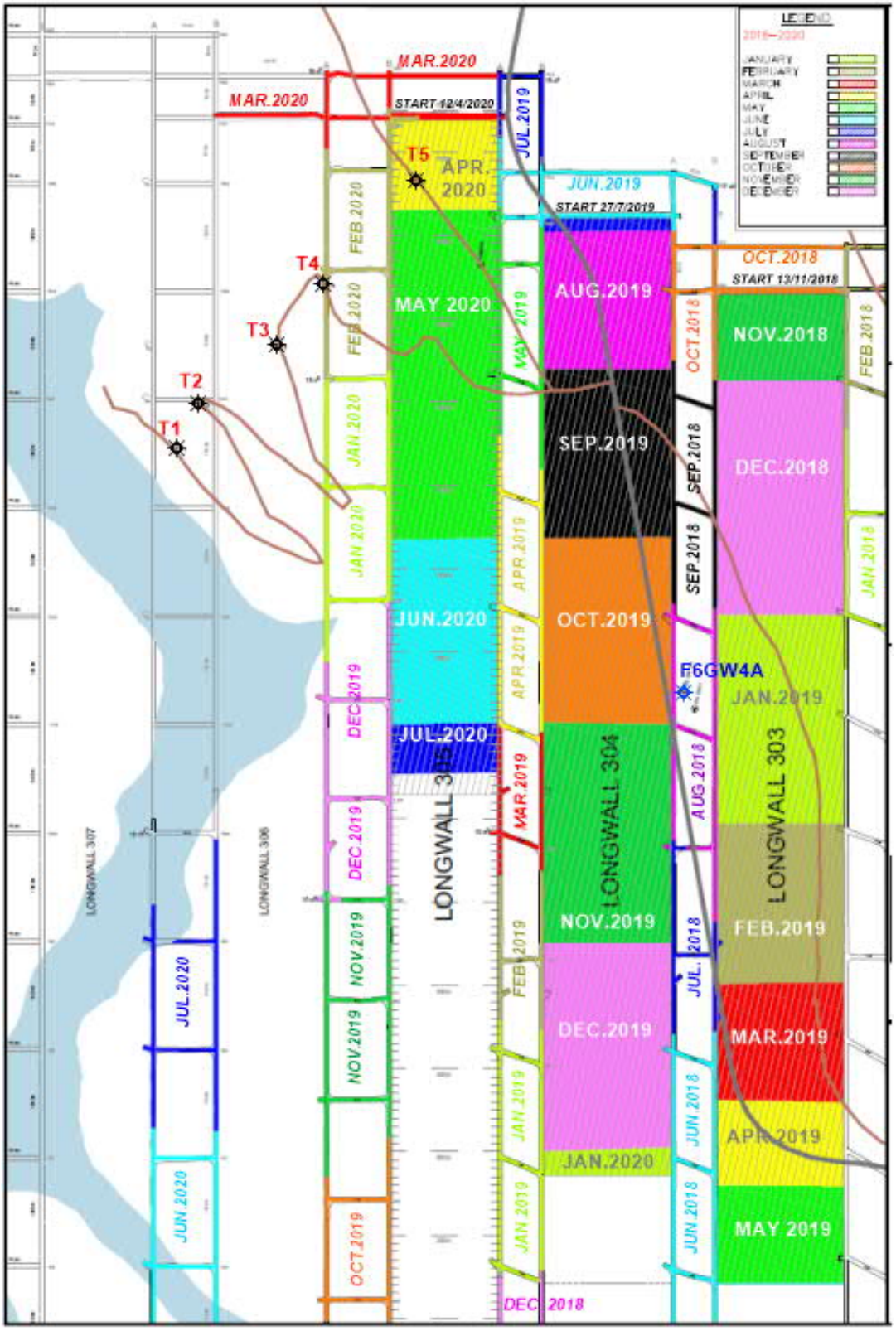


Figure 5 Mining progression for Longwalls 303 to 305

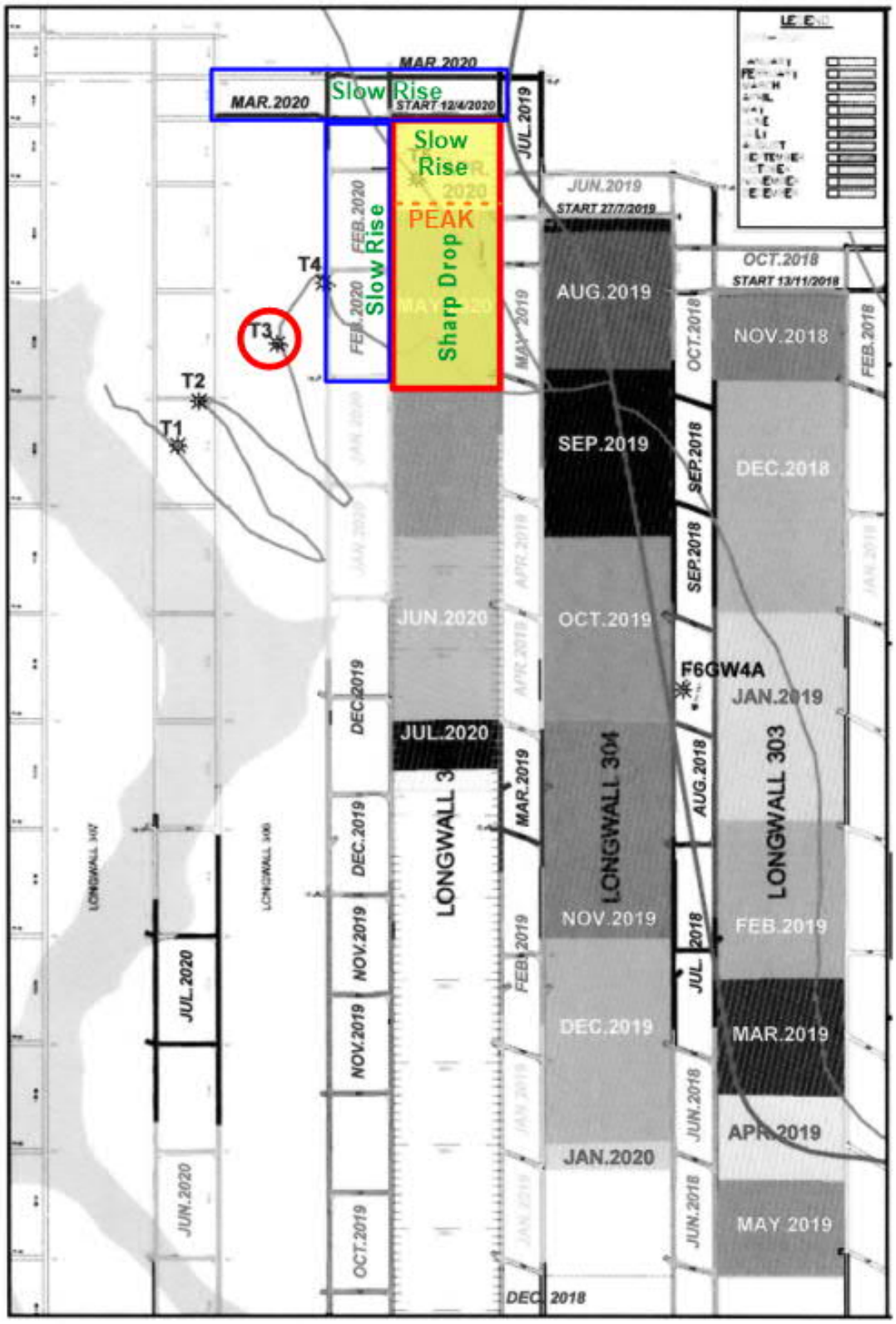
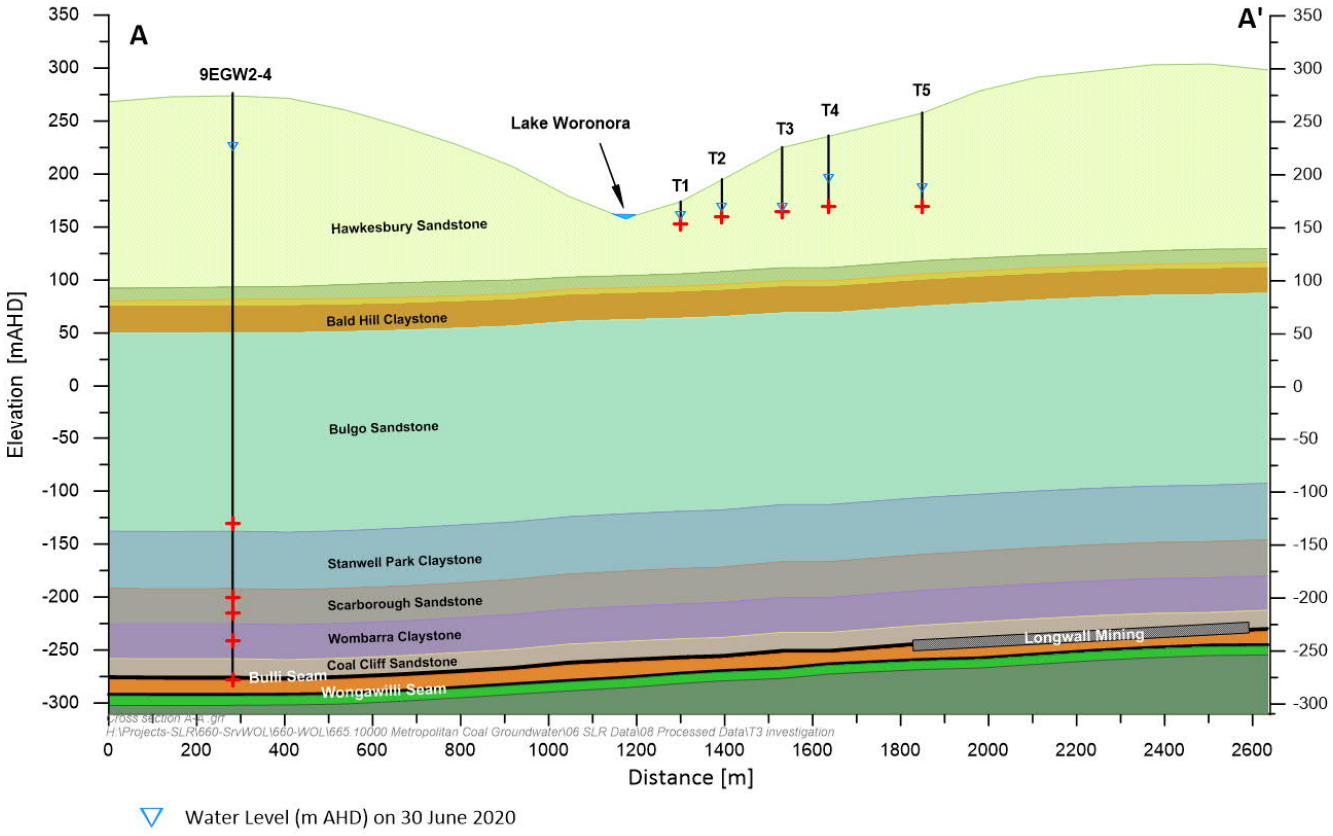


Figure 6 Mining progression at the time of the T3 disturbance (February-May 2020)



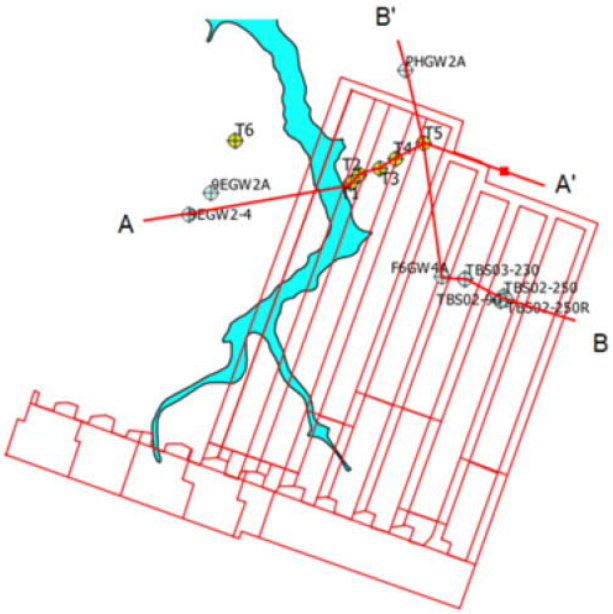
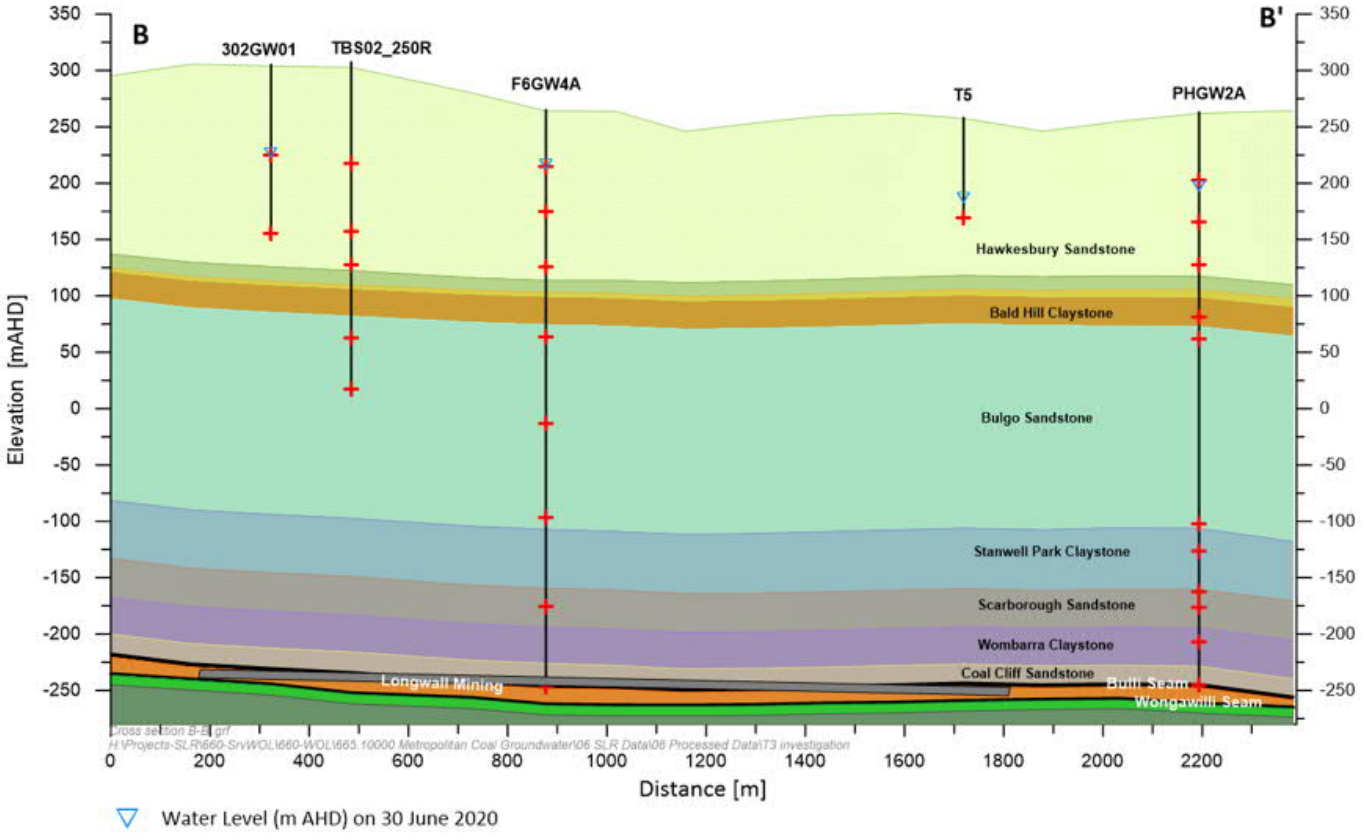


Figure 7 West-to-east geological cross-section A-A'



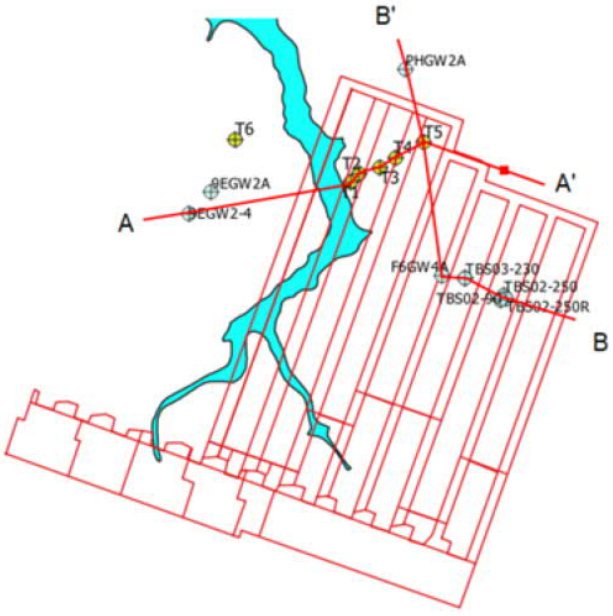


Figure 8 South-to-north geological cross-section B-B'

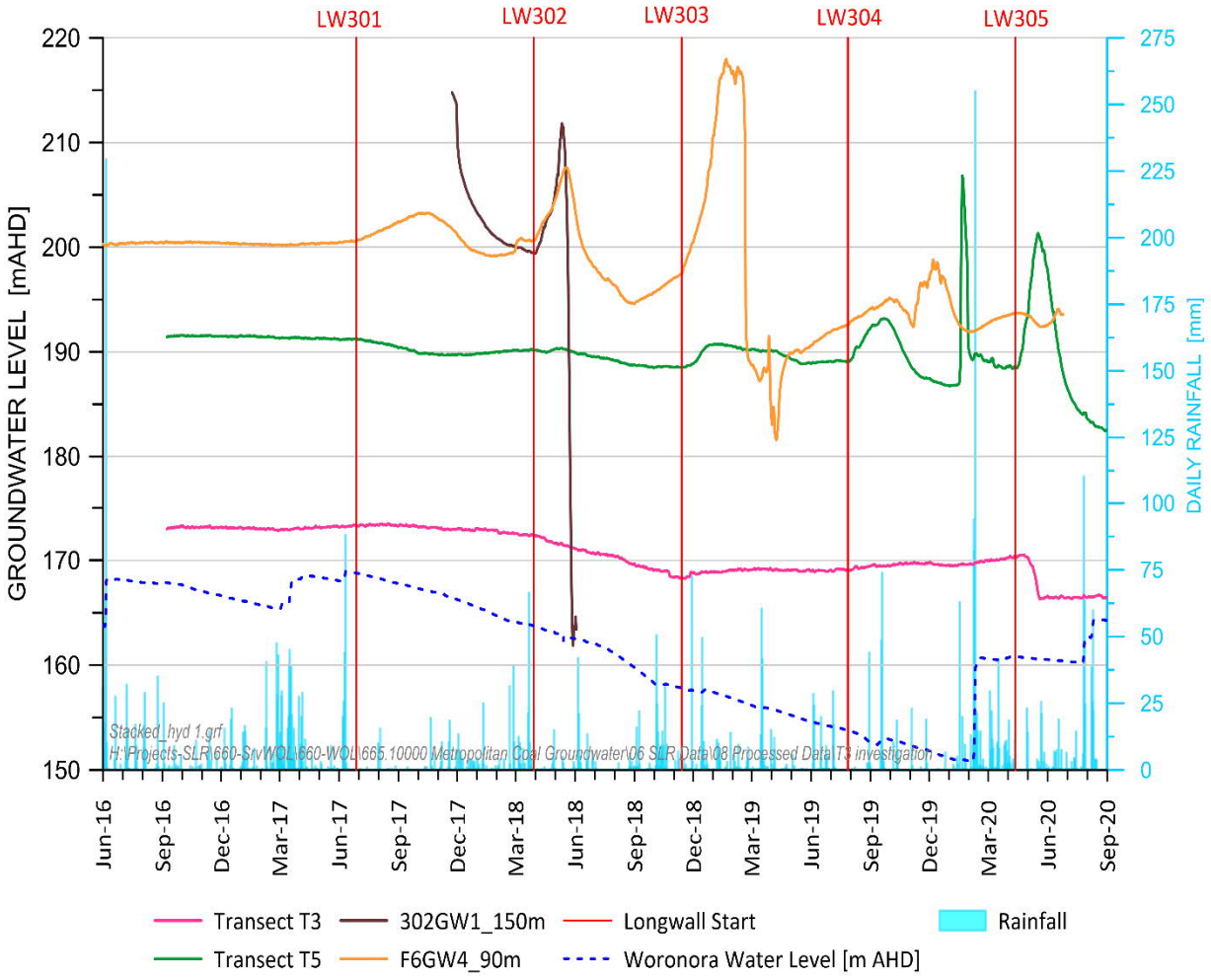


Figure 9 Groundwater hydrographs for bore T5 compared with reservoir water level, rainfall, bore T3 and neighbouring VWP sensors at a similar elevation

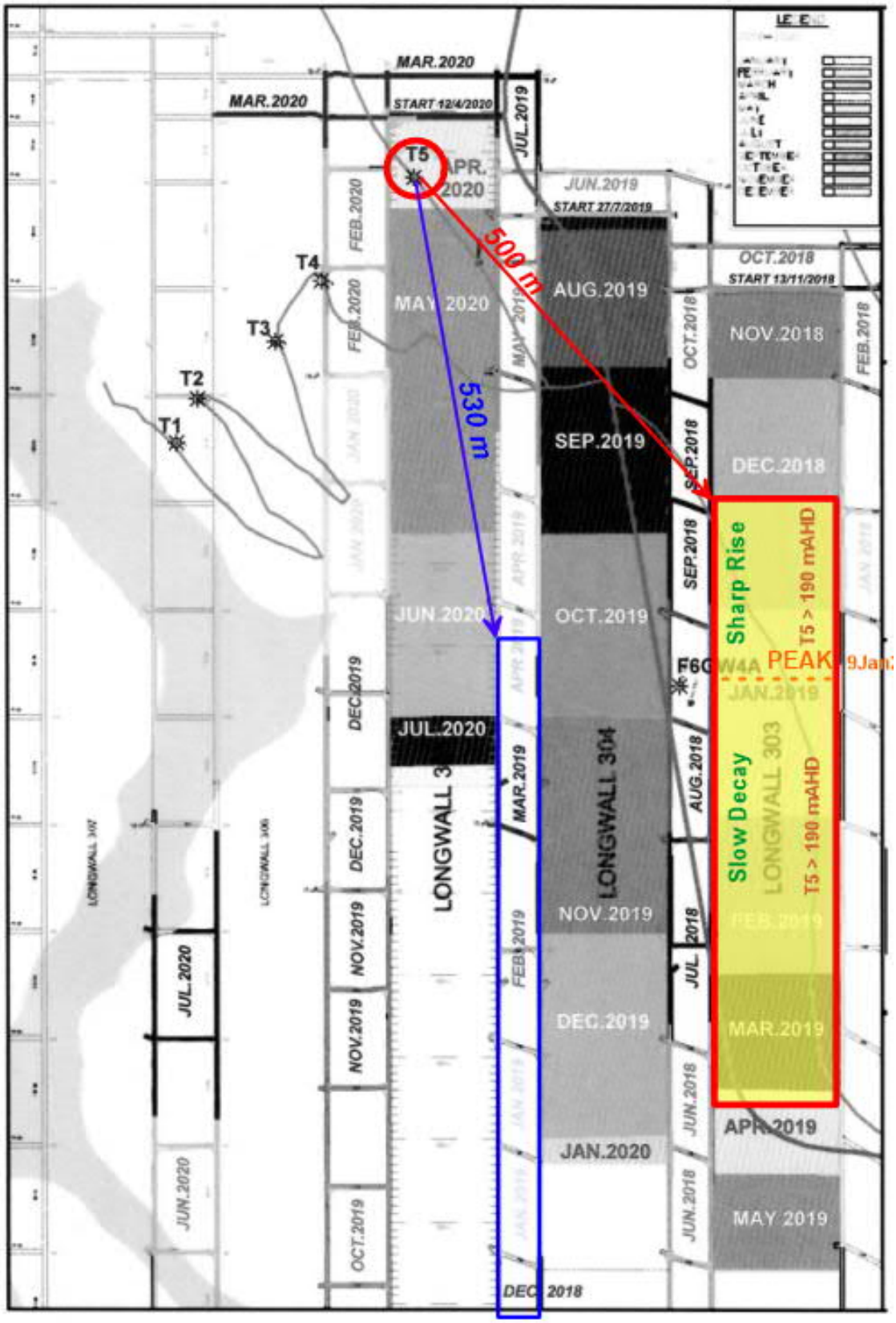


Figure 10 Mining progression at the time of the T5 disturbance (December 2018 - March 2019)

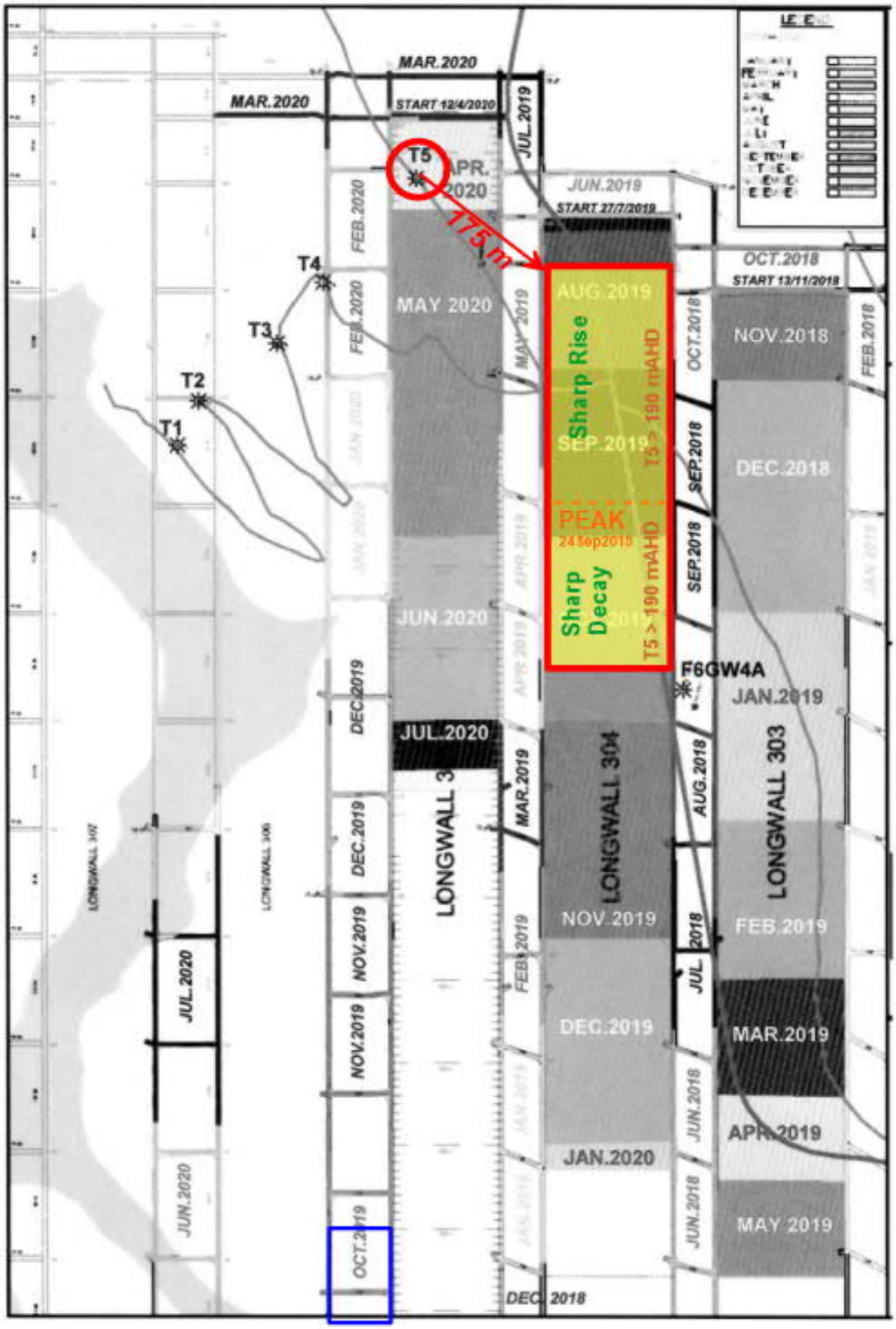


Figure 11 Mining progression at the time of the T5 disturbance (August - October 2019)

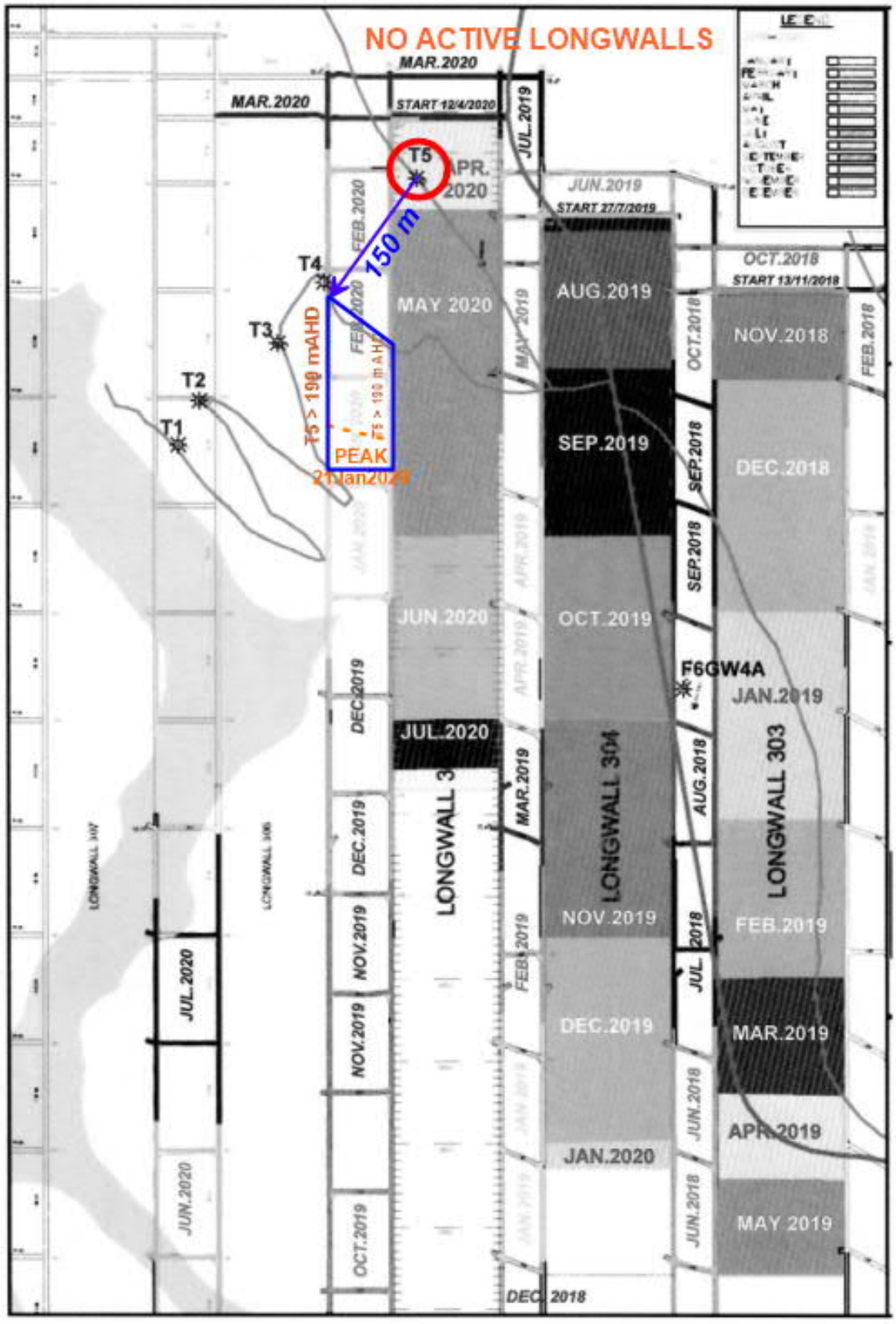


Figure 12 Mining progression at the time of the T5 spike disturbance (January 2020)

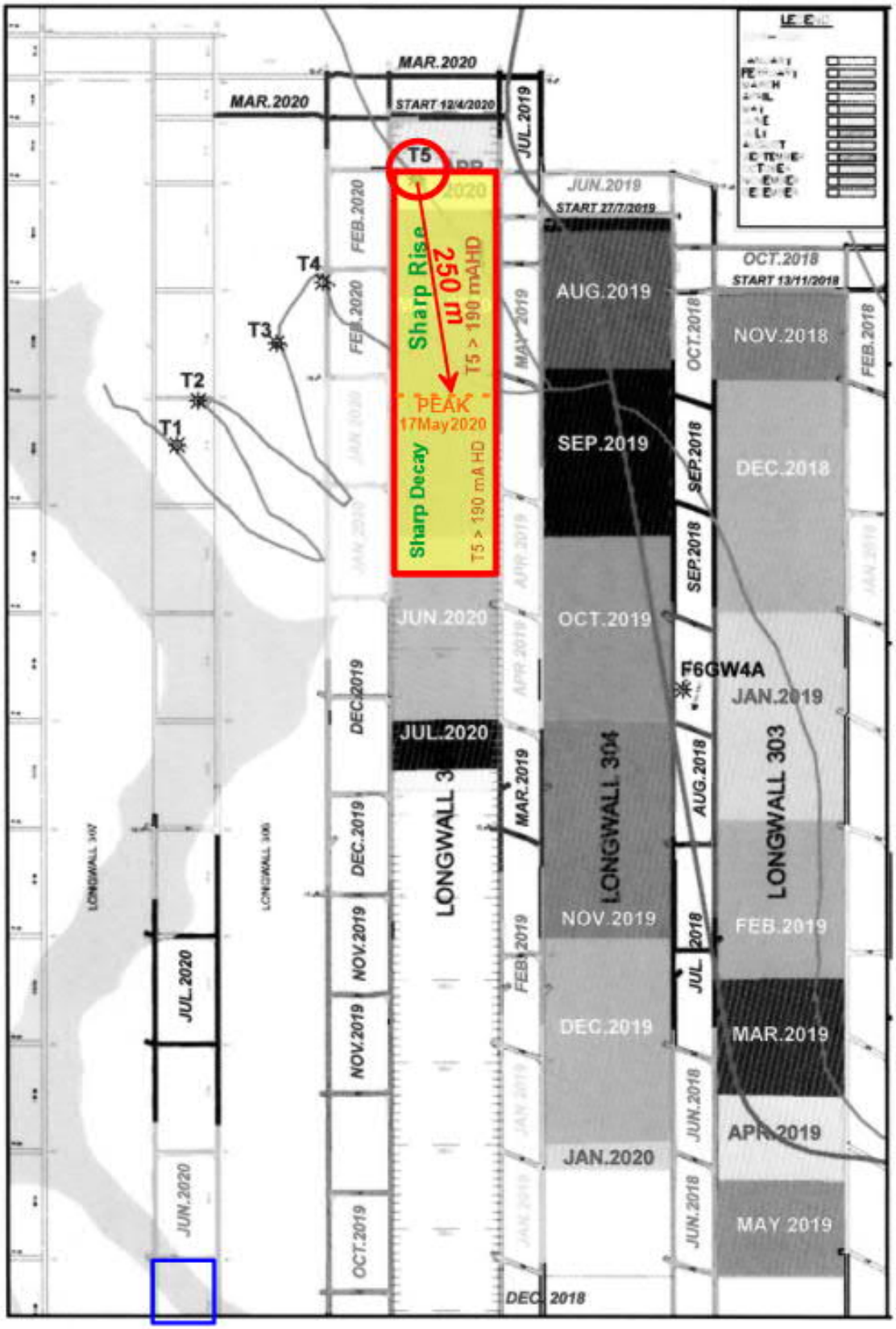


Figure 13 Mining progression at the time of the T5 disturbance (April - June 2020)