Appendix E – Myrtle Creek Rehabilitation Report

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TAH5179A_Rev1

Dear Andrew

UPDATE OF REMEDIATION OUTCOMES AT POOL 23 ON MYRTLE CREEK

Please find herein an update of remediation outcomes at Pool 23 on Myrtle Creek following Stage 1 of the Corrective Management Action Plan (CMAP) for Myrtle Creek.

1. INTRODUCTION

Myrtle Creek, a tributary to the Nepean River, defines the northern boundary of the township of Tahmoor in the Southern Highlands of New South Wales. The creek was incrementally impacted by the subsidence associated with longwall mining at Tahmoor Coal Mine leading to cracking of rock in the creek bed and loss of surface water from the creek. Tahmoor Coal Pty Ltd (Tahmoor Coal), the owner of the mine, completed Stage 1 of the CMAP at Pool 23 in February 2020. Tahmoor Coal commissioned SCT Operations Pty Ltd (SCT) to prepare this report updating the remediation outcomes at Pool 23 to mid-September 2020.

Figure 1 shows comparative photographs of Pool 23 before and after remediation.

The remediation trial at the Pool 23 rock bar on Myrtle Creek has shown a pattern of polyurethane injection into the fracture network to be effective as a strategy to maintain water in a subsidence impacted pool for an extended period. Aesthetic values have improved since remediation was completed and the pool returned to overflow level. SCT understands that the boreholes used for the remediation have been filled with textured concrete blend to reduce any signs of the work having taken place.

Monitoring indicates that the water level in Pool 23 has remained full or close to full since the work was completed and a heavy rainfall event on 6 February 2020 filled the pool. A grout curtain wall in a similar arrangement however with less emphasis on characterisation is likely to be effective at other sites where remedial action may be required.

a) 15 February 2019.

b) 20 August 2020.

Figure 1: Comparative photographs of Pool 23 before and after remediation.

This report is structured to present:

- a description of the Pool 23 site and a summary of the remediation work that was undertaken
- a review of the monitoring undertaken since the completion of remediation works
- recommended improvements to simplify the completion criteria and make them more relevant at other sites
- next steps for monitoring Pool 23.

2. Site Description and Remediation

Figure 2 shows a plan of Myrtle Creek and the location of Pool 23 superimposed onto a 1:25,000 topographic series map of the area. The catchment upstream of the site is approximately 7km^2 in area. Average rainfall between 2004 and 2016 is approximately 760mm/yr.

There is a flow station known as M7 located approximately 520m downstream of Remembrance Drive at CH1909m. This station has been in operation since 2010 and provides a near continuous record of the flow in the creek at this point. The catchment area above M7 is approximately 8km^2 in area. Figure 3 shows the time weighted stream discharge duration curve for Myrtle Creek. This plot shows that natural flow in Myrtle Creek averages approximately 1Ml/day but is less than 0.1Ml/day for approximately 15% of the time.

Pool 23 was incrementally impacted by the subsidence associated with longwall mining at Tahmoor Coal Mine from Longwall 26 to Longwall 28 leading to cracking of rock in the creek bed and loss of surface water from the creek so that Pool 23 was mostly dry. Myrtle Creek was undermined by Longwall 26 during mid – end August 2011, Longwall 27 early – late March 2013, and Longwall 28 mid-May – early June 2014.

A Section 240 Notice was issued by the Division of Resources and Geoscience on 5 December 2016 (Tahmoor Coal 2019) leading to the development of the Myrtle Creek Plan (CMAP). Myrtle Creek CMAP was approved by the NSW Resources Regulator on 11 October 2018.Tahmoor Coal, the owner of the mine, contracted Pointe Engineering Pty Ltd (Pointe) to undertake a remediation trial at Pool 23 using polyurethane filler. Characterisation work was undertaken between 23 September 2019 and 11 November 2019. Remediation works began in early October 2019 and were completed in early-February 2020.

Remediation works involved filling mining induced fractures in the rock retaining Pool 23 and in the bed of Myrtle Creek immediately upstream with a hydrophobic polyurethane resin (PUR) called Spetec H100). Details of the work are described in Pointe Engineering (2020) from which the following summary is drawn.

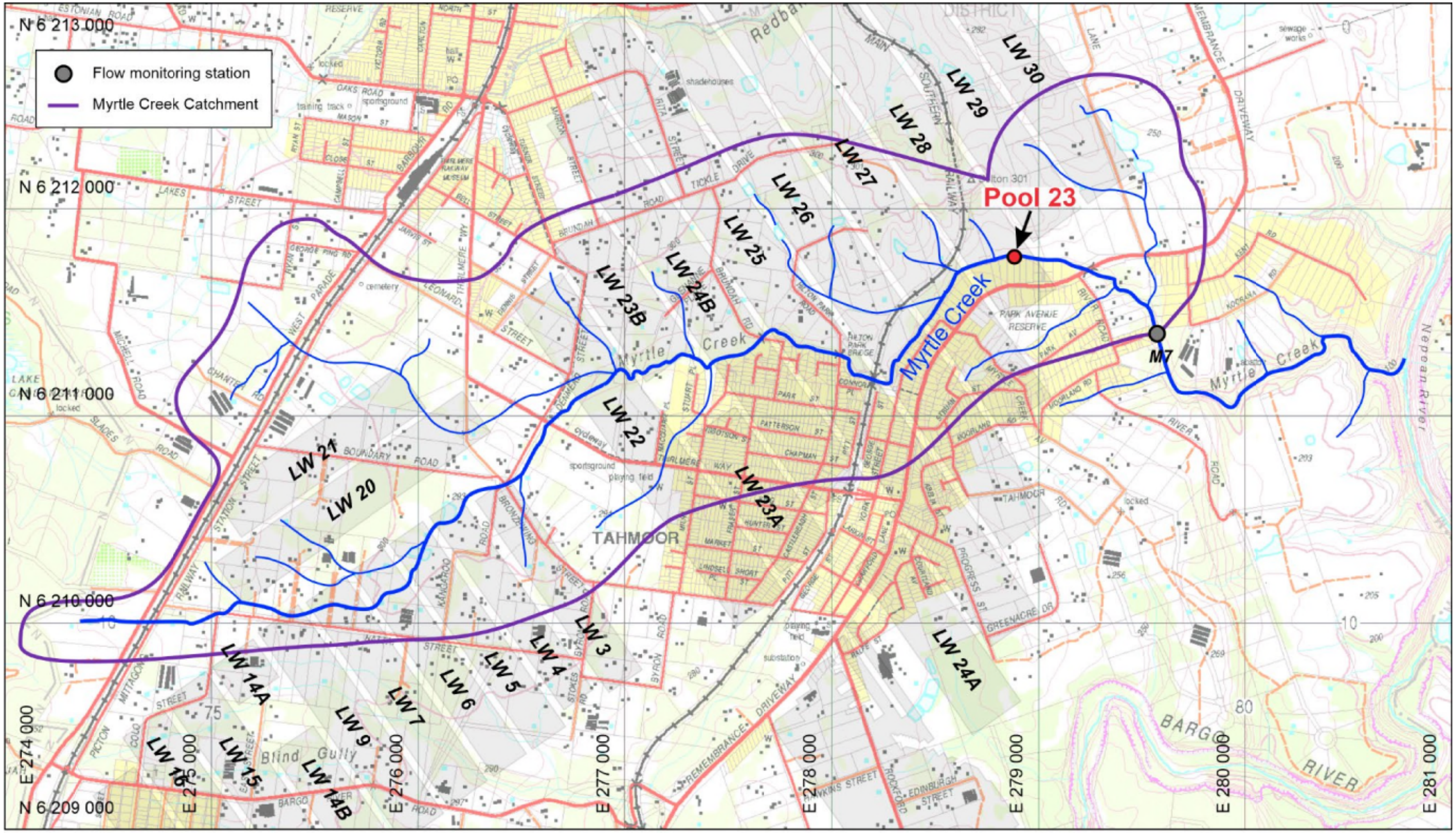


Figure 2: Site plan showing Myrtle Creek catchment and location of Pool 23 relative to longwall panels superimposed on a 1:25,000 topographic series base.

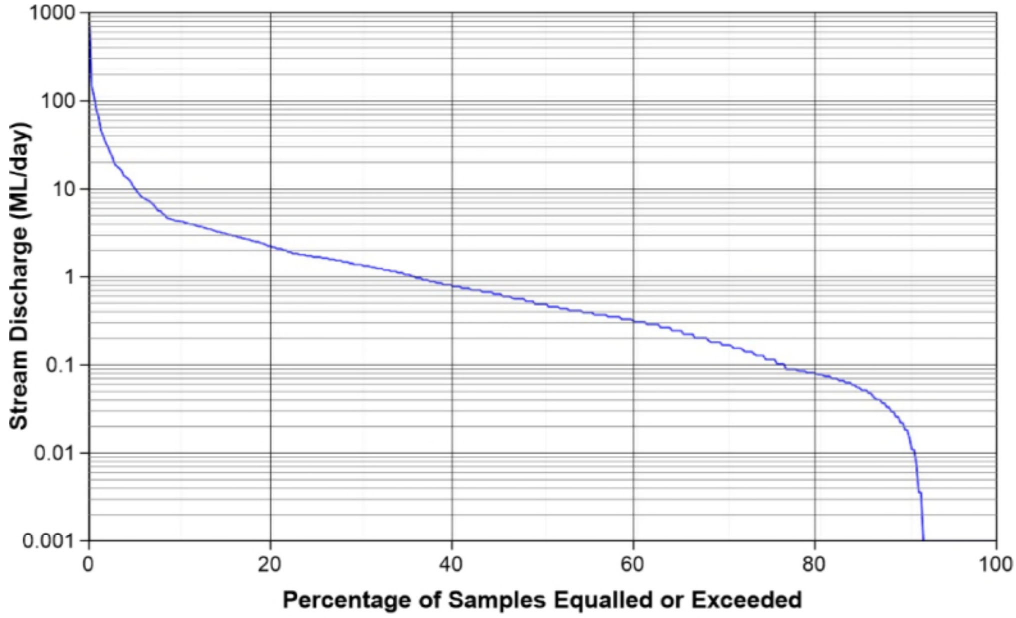


Figure 3: Time weighted stream discharge duration curve (after Hydrometric Consulting Services 2020).

PUR filling was undertaken in four stages:

1. a curtain wall to 17m below rock bar taking 1200 litres of PUR
2. a curtain infill to 2m below the rock bar taking 400 litres of PUR
3. a grid pattern to 1m in the floor of Pool 23 taking 420 litres of PUR
4. a curtain infill to 7m below the rock bar taking 1500 litres of PUR.

The approximate fill patterns from these four stages are shown in Figure 4.

The remediation works began as ten characterisation boreholes drilled across the site between 23 September 2019 and 11 November 2019. These boreholes were nominally 4m apart with two left out because of surface constraints. The boreholes were drilled in a line stretching 44m across the rock bar downstream of Pool 23 perpendicular to the creek flow. The boreholes were drilled vertically to a depth 17m below the rock bar overflow. Fractures were characterised along the full length of each borehole using a borehole camera, calliper log and packer testing. The core was also inspected and logged.

A baseline pool recession rate (PRR) test was undertaken on 3 October 2019. Approximately 13,000 litres of water were pumped into Pool 23 and the rate of lowering of the water level was monitored. The water level dropped to empty in a few hours.

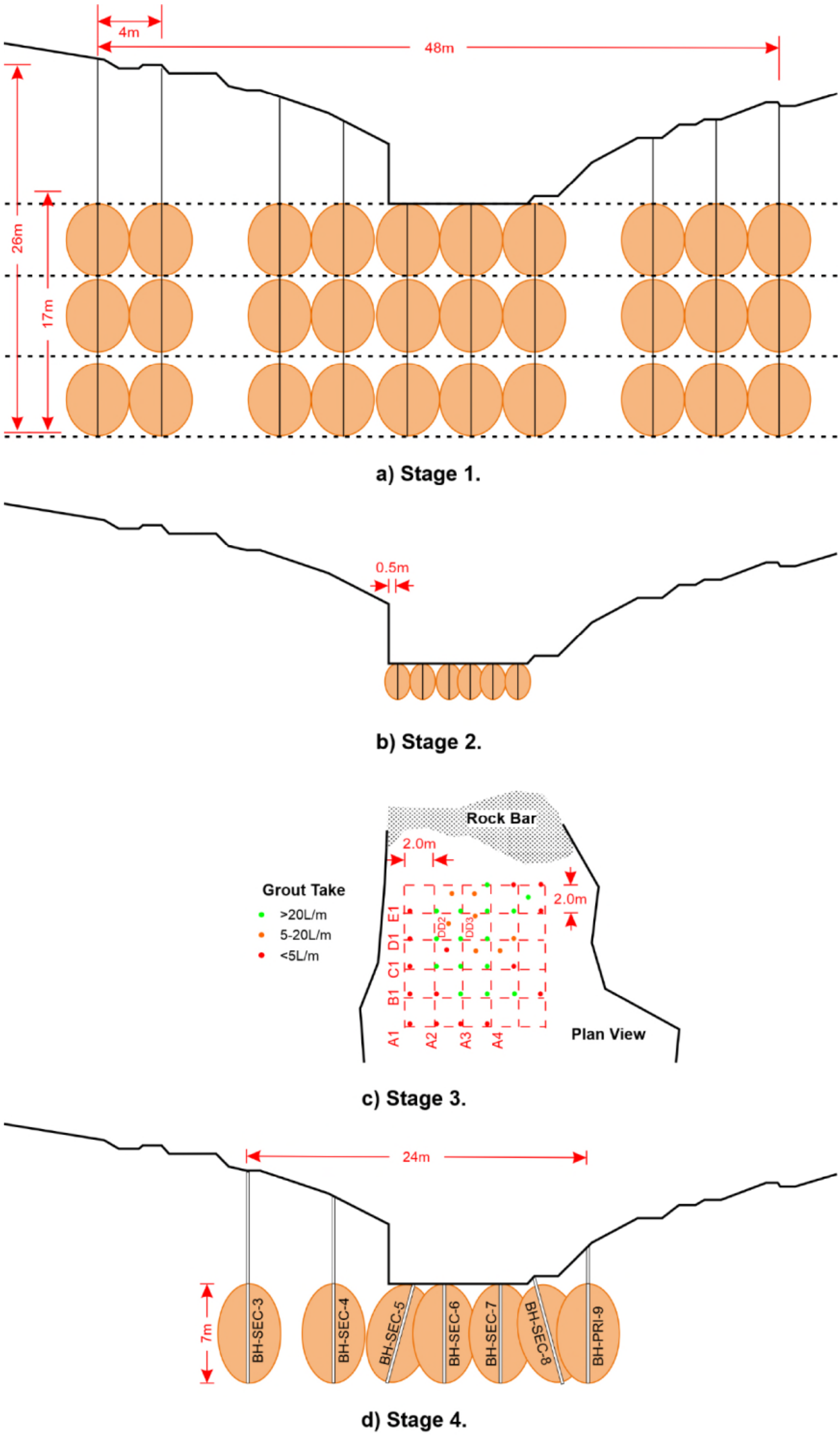


Figure 4: Stages of PUR Grouting at Pool 23.

Stage 1 grouting involved injection into the characterisation boreholes in three intervals from the bottom up. Although 1200 litres of PUR were injected, the cross flow between holes limited the effectiveness of this initial treatment. No change in PRR was observed.

Stage 2 grouting involved injecting 400 litres of PUR into twenty, 38mm diameter holes drilled to 2m below surface of the rock bar using a pneumatic hammer. The initial line of holes across the rock bar was split and secondary, tertiary, and quaternary holes drilled and injected at a final spacing of approximately 0.5 m. A reduction in PRR was observed with the water level taking 20 hours to drop to empty.

Stage 3 grouting involved injecting 450 litres of PUR into 37, 1m deep holes drilled into the floor of Pool 23 on an approximately 2m grid extending 12m by 14m with some infill holes. A further reduction in PRR was observed with the water level taking approximately 100 hours to drop to a residual level.

Initial characterisation drilling confirmed the presence of a significant fracture system at approximately 6m below the surface of the rock bar. Stage 4 grouting targeted this fracture system. Seven, 76mm diameter boreholes were drilled to a depth of 7m below the rock bar along a 24m section along the alignment of the Stage 1 grouting. The holes were drilled using a portable drill rig and mud flush system. In total, approximately 1500 litres of PUR in total were injected into these holes.

A heavy rainfall event commencing 7 February 2020 that continued for nearly a fortnight coincided with the end of the Stage 4 injection. Pool 23 filled during that event and has remained full since.

3. Monitoring of Pool 23

The intent of the remediation is to return water to surface pools for extended periods consistent with the pre-mining state of Myrtle Creek.

Figure 5 shows the water level measured in Pool 23 since 2010 and the rainfall residual over the same period. Prior to mining beneath Myrtle Creek, Pool 23 remained substantially full, even during extended periods without rain. The progressive impacts of mining Longwalls 26, 27 and 28 are apparent in the water level of Pool 23. Between September 2011 and completion of remediation in February 2020, increasingly rapid drops in pool level following flow events associated with heavy rainfall and extended periods when the pool was empty are evidence of the increased fracturing associated with mining each successive longwall panel.

Remediation activities in late 2019 and early 2020 show an increase in pool level back to slightly above pre-mining levels. The discrepancy between pre and post mining levels is most likely a result of subsidence movements and re-establishment of the flow level monitoring device.

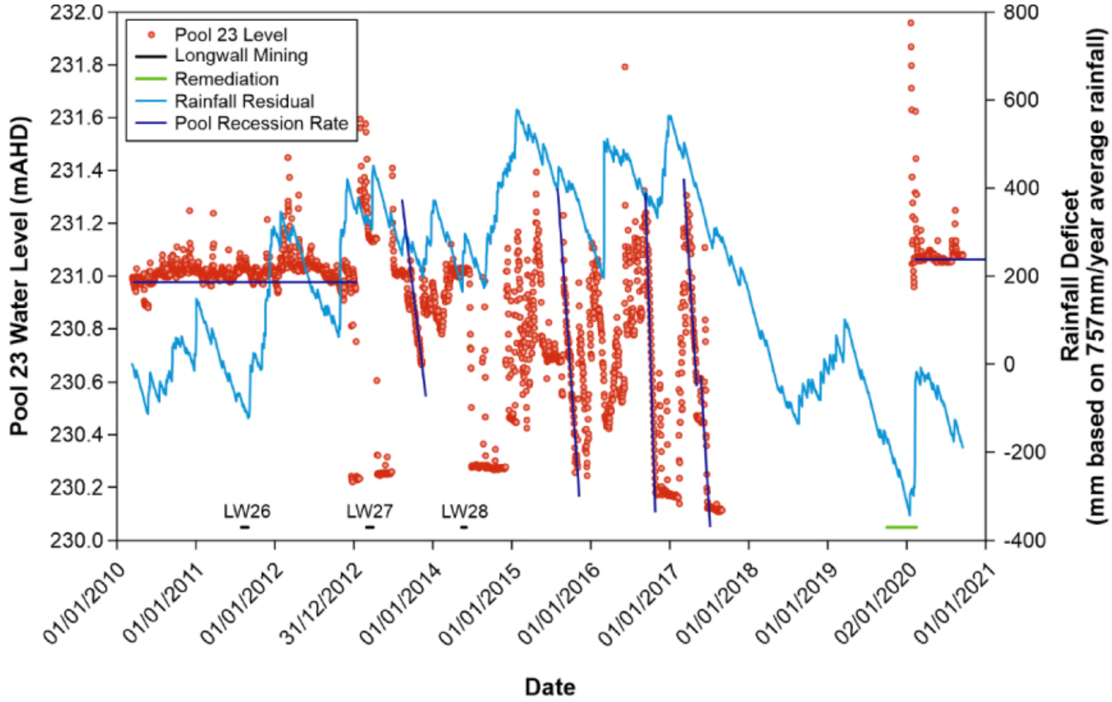


Figure 5: Water level in Pool 23 observed since 2010 and rainfall deficit over the same period.

Long term rainfall trends are apparent as the running difference between a long-term average and the cumulative rainfall that is measured to any given point in time. This difference is referred to as rainfall residual or rainfall deficit. Heavy rainfall events are evident as sharply increasing values of rainfall residual. Decreasing rainfall residual indicates extended periods of below average rainfall.

Since the beginning of 2017, there has been an ongoing trend of below average rainfall. Lower rainfall residual is expected to result in lower flows in Myrtle Creek and increased potential for Pool 23 to fall below full. However, since the remediation was completed in early 2020, there is no evidence of Pool 23 dropping below full even though the rainfall residual remains low and cumulative rainfall below long-term average.

Experience in the Bargo River and at other sites indicates that when a pool remains substantially full, biological activity and sediment trapped within the pool will gradually seal any remaining leakage paths. Visual observations suggest that these natural processes are taking place at Pool 23.

The flow regime in Myrtle Creek is such that there are times when there is very low flow and under these conditions evaporation rates are recognised as sufficient to reduce pool levels. The challenge for assessing remediation effectiveness is finding a completion criterion that achieves the intent of maintaining Pool 23 full for extended periods of no rain.

Pool 23 has remained full and overflowing for the eight months since remediation activities were completed in early February 2020. It appears likely that Pool 23 has been successfully remediated, but ongoing monitoring over an extended period is recommended to confirm this success.

4. Implications for Completion Criteria at Other Sites

The intent of the remediation is to return water to surface pools for extended periods consistent with the pre-mining state of Myrtle Creek. The flow regime in Myrtle Creek is such that there are times when there is very low flow and under these conditions evaporation rates may reduce water levels in some pools as it did prior to mining. The challenge for determining remediation effectiveness is finding a completion criterion that achieves the intent of the remediation.

Learnings from Myrtle Creek CMAP demonstrated that indirect methods based on hydraulic conductivity measurements or percentage fracture filling are not able to be measured reliably and do not directly indicate successful remediation. We recommend that indirect criteria based on borehole testing should not be used as a measure of remediation success.

We recommend instead to determine remediation effectiveness using pool recession rate (PRR) as the criteria because this rate directly measures whether the intent of the remediation has been met. PRR testing involves part filling the pool with a large volume of water, nominally 10,000 litres and measuring the rate at which the water level recedes. When the recession rate is low enough that water is retained within the pool for extended periods without the level dropping significantly, the remediation can be considered effective.

PRR testing is complicated by the background flow in the creek. If the flowrate is high, even pools that have not been remediated run full. However, when the flowrate drops, leakage through subsurface fracture networks accounts for a larger proportion of total flow and eventually all flow is accommodated within the fracture network and surface pools no longer contain water.

Reducing the PRR of a pool to a level where the pool remains full most of the time provides a good environmental outcome. To confirm this success over a longer term, we recommend remediated pool levels are monitored for approximately two years. Experience in the Bargo River and at other sites indicates that pools that hold water for extended periods tend to self-seal. If a pool can be remediated to the extent that it holds water most of the time over two years, its ability to hold water is likely to improve further with time.

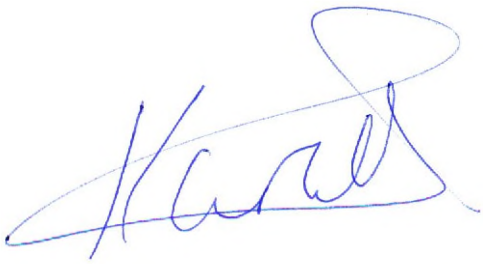
For future sites, the PRR test appears likely to provide the most relevant method for determining remediation effectiveness during the period of treatment. Monitoring pool levels and natural recession rates over an extended period of time provides a method of confirming overall remediation success. Indirect methods based on hydraulic conductivity measurements or percentage fracture filling are not able to be measured reliably and do not directly indicate successful remediation.

5. Further Monitoring at Pool 23

The existing monitoring of water levels at Pool 23 appears to provide convincing evidence of remediation success at this site. After a period of 8 months remaining full, it is very likely that Pool 23 will continue to remain full as natural remediation processes take over. If a continuation of this monitoring until the end of 2021, a period of two years since remediation, shows Pool 23 remains full, it would be reasonable to contend that the completion criteria has been met.

If you have any queries or require further clarification of any of the issues raised, please do not hesitate to contact me.

Yours sincerely



Ken Mills
Principal Geotechnical Engineer

References

Hydrometric Consulting Services 2020, Time Weighted Stream Discharge Duration Curve, Output 16 November 2020.