NEW GOLD RAINY RIVER MINE
APPENDIX C
PAG COVER TRIAL FACTUAL DATA REPORT

Rainy River Mine – Potentially Acid Generating Mine Rock Cover Trial 2022 Annual Monitoring Report

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EXECUTIVE SUMMARY

New Gold Inc. (New Gold) has developed cover system designs for the closure of the potentially acid generating (PAG) mine rock stockpiles (MRSs) at Rainy River Mine. New Gold has implemented cover system field trials to evaluate the cover system design's effectiveness to limit acid rock drainage (ARD). Okane Consultants (Okane) was retained to design, instrument, and interpret monitoring data collected from performance monitoring systems installed at the cover system field trials. The objective of this report is to summarize and interpret findings from data collected during the monitoring period of November 1, 2021 to October 31, 2022, and a comprehensive three-year monitoring period between November 1, 2019 and October 31, 2022.

The primary objectives of the cover system field trials are to evaluate the ability of overburden clay to manage oxygen ingress and net percolation (NP) through altering the water and gas balances. Two cover system field trials were constructed in fall of 2017. Trial #1 consists of 0.50 m compacted Brenna clay (CBC), 0.75 m non-compacted clay overburden, and 0.25 m topsoil. Propagules present in the topsoil layer aided re-vegetation on Trial #1. Trial #2 consists of 0.50 m CBC and 1.0 m non-compacted clay overburden. Re-vegetation was completed by both hand-seeding an appropriate seed-mix on Trial #2 in July 2019 as well as hydroseeding in late 2019.

The ability of the cover system to manage oxygen ingress is evaluated by monitoring the degree of saturation of the CBC layer. A cover system containing a layer maintained at a degree of saturation equal to or greater than 85% is generally expected to efficiently limit oxygen ingress (McMullen et al., 1997, MEND, 2004). During the 2021-2022 monitoring period, the annual average saturation levels measured for both Trial #1 and Trial #2 was greater than 95% in the CBC layer. Maintenance of a 95% degree of saturation in the cover system demonstrated that the compacted clay layer is retaining sufficient pore-water to prevent advective oxygen transport, and limit oxygen ingress through diffusion. The 2021-2022 monitoring period observed the degree of saturation of the CBC drop to 91% and 83% at Trial #1 and Trial #2, respectively. The decrease in degree of saturation was minimal, and a result of as-expected water cycling coupled with peak temperatures during a drier period at the end of July. Precipitation following this period, as well as cooler temperatures, allowed saturation levels in the CBC to rebound to historically maintained levels.

Oxygen diffusion into the mine rock was estimated using the collected field performance data within a numerical gas flow model. Using cover system material properties and the degree of saturation measured over the monitoring period, oxygen diffusion was estimated to be approximately 1 mol/m^2/year for Trial #1 and 1.4 mol/m^2/year for Trial #2. This is considered a very low oxygen flux as outlined by the International Network for Acid Prevention (INAP) Guidance Document (INAP, 2017). Oxygen diffusion rates increased slightly in June 2022 at both Trial #1 and Trial #2 as the water content and associated degree of saturation of the cover system's compacted and non-compacted overburden layers was reduced due to less rainfall. Overall, both Trial #1 and Trial #2 demonstrated very low oxygen ingress rates throughout the entirety of the year.

Numerical simulation water balances were developed for each cover system configuration to estimate NP of meteoric waters into the underlying mine rock. The total estimated NP over the monitoring year was 12.5% and 14% for Trial #1 and Trial #2, respectively. Runoff was observed to be higher than predicted by the conceptual model (10 - 20%) at 41% and 39.5% for Trial #1 and Trial #2, respectively. This was due to the excess rainfall observed during the monitoring period, which was 310 mm, or 156%, higher than the 30-year historic average. Runoff is expected to lessen to values more aligned with the conceptual model under more typical annual precipitation conditions.

Performance monitoring of cover system's provides essential insight into cover system response to climatic variation in terms of temperature and water storage dynamics. The monitoring systems installed at Rainy River are providing data required to assess the performance trajectories for the site. Continued monitoring and reporting offers insight to field-derived material properties and the opportunity to optimize future closure activities at site.

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New Gold Inc. (New Gold) has developed cover system designs for the closure of the potentially acid generating (PAG) mine rock stockpiles (MRSs) at Rainy River Mine. New Gold has implemented cover system field trials to evaluate the cover system design's effectiveness to limit acid rock drainage. Okane Consultants (Okane) was retained to design, instrument, and interpret monitoring data collected from performance monitoring systems installed at the PAG mine rock cover system field trials. This report summarizes and provides interpretation of both the monitoring data obtained between November 1, 2021 and October 31, 2022 (referred to herein as 'the monitoring period'), as well as a three-year period between November 1, 2019 and October 31, 2022 (referred to herein as 'the three-year monitoring period').

1.1 Project Objectives and Scope

The objectives of the PAG mine rock cover system field trials are to:

1) Evaluate overburden clay as a potential cover material for mitigation of oxygen ingress during stockpile construction (operations) due to advective airflow;
2) Evaluate the effectiveness of compacted overburden clay as a low hydraulic conductivity barrier layer and overlying protective growth medium cover borrow material for mitigation of NP and oxygen ingress (closure); and
3) Update and refine conceptual models of performance for the cover system field trial area through examining water balance components (e.g., precipitation, runoff, evapotranspiration, water storage, etc.).

1.2 Report Organization

For convenient reference, this report has been subdivided into the following section:

- Section 2 – provides pertinent background information of the cover system field trials and a summary of activities completed during the monitoring period;
- Section 3 – presents and discusses field data collected during the monitoring period, as well as discusses the performance of the cover system over a three-year monitoring period;
- Section 4 – provides recommendations for the following monitoring period.

2 BACKGROUND

2.1 Description of Cover System Field Trials

Construction of the cover system field trials commenced October 2017 and was completed early November 2017. The constructed field trials span an approximate area of 65 m × 100 m with a 1 to 2% sloping plateau of ~3,000 m^2. A 3H:1V slope was constructed on the north, east and west slopes. Two enhanced store-and-release, low permeability layer cover systems were constructed to meet the objectives stated in Section 1.1. Trial #1 consists of 0.50 m compacted Brenna clay (CBC), 0.75 m non-compacted clay overburden, and 0.25 m topsoil. Propagules present in the topsoil layer provided re-vegetation on Trial #1. Trial #2 consists of 0.50 m CBC and 1.0 m non-compacted clay overburden. Re-vegetation was initiated by hand-seeding an appropriate seed-mix on Trial #2 in July 2019, and later hydroseeded in autumn 2019. Complete as-built details can be found in Okane Report No. 1003/08-001 (2018).

Okane installed and commissioned meteorological and in-situ instrumentation throughout the trial area to monitor cover system performance over time under site specific conditions. Two instrumentation nests (Primary and Secondary) were installed in both Trial #1 and Trial #2 areas. Primary nests consist of a full arrangement of sensors throughout the cover system profile. Secondary nests consist of a reduced number of sensors and was implemented to ensure data redundancy in the profile. The following in-situ instrumentation was installed in each trial area:

- Eleven matric suction sensors (Campbell Science International [CSI] 229) to measure suction (i.e., negative pore-water pressure) and soil temperature;
- Fourteen water content sensors (CSI 616) to measure in situ volumetric water content; and,
- Six oxygen sensors (Apogee SO-110) to measure differential oxygen concentrations above and below the CBC.

Two meteorological instruments were installed on Trial #2. A Texas Electronics model 525M tipping bucket rain gauge (TBRG) to capture trial area specific rainfall events and a Kipp & Zonen NR-LITE2 net radiometer to monitor hourly averages and daily totals of net radiation (i.e., the sum of incoming and outgoing all-wave radiation). The tipping bucket and net radiometer are used to determine theoretical maximum potential rates of evaporation from the cover system surface. Additional site-specific meteorological data will be collected from New Gold's on-site weather station.

2.2 Conceptual Model of Cover System Performance

A conceptual model of cover system performance was developed by Okane. The conceptual model was used to identify key processes and mechanisms, and then evaluate the cover system design's control on those mechanisms under a range of potential scenarios. It was identified that weathering (oxidation) and leaching (net percolation) in the MRSs will cause acid rock drainage and have negative environmental effects on the receiving environment. The cover system designs aim to provide controls on oxygen ingress and NP to limit acid rock drainage.

Diffusion and advection represent the primary mechanisms for oxygen transport through a cover system. Oxygen diffusion can be restricted by decreasing the bulk diffusion coefficient of the cover system, generally by increasing the degree of saturation. A cover system containing a layer maintained at a degree of saturation equal to or greater than 85% is expected to efficiently limit oxygen ingress (McMullen et al., 1997, MEND, 2004). The compacted clay layer incorporated in both cover system configurations is designed to provide higher water retention characteristics of the cover system profile. It is expected that the compacted layer will maintain a degree of saturation greater than, or close to 85% for the majority of the climate cycle. Limiting advective transport of oxygen requires the cover to restrict air flow by reducing pressure and thermal gradients or the permeability of the material. The compacted clay layer aims to reduce permeability of the material to limit advective air movement.

NP is limited by taking advantage of the store-and-release properties of the 1 m non-compacted layer. Infiltrating water is stored within the cover system so it can be subsequently released via transpiration and evaporation. A store-and-release system uses the variability in timing, volume, and intensity of precipitation events to take advantage of available evaporative energy during summer. Additionally, the compacted layers form a barrier-type cover system which limits NP by reducing the hydraulic conductivity within the layer.

The conceptual model was based on Rainy River Mine's site-specific climate, hydrogeological setting, and materials. Given the site-specific climate of the Rainy River Mine, the conceptual ranges of performance could be classified as very low NP (5 to 15% of average annual precipitation) and very low oxygen flux (1 to 5 mol/m^2/year) according to the INAP Guidance Document (INAP, 2017).

2.3 2021 – 2022 Monitoring Activities

The cover system field trials were monitored by Okane personnel throughout the monitoring period. Major activities that were completed on the field trials include automated data collection and data QA/QC, field inspections and instrumentation maintenance, snow survey, and cover system performance updates (Table 2.1).

Table 2.1: Monitoring period activities.

Activity	Date
Automated Data Download and QA/QC	February 22, May 28, July 7, August 2, August 29, September 27, and November 4, 2022
Snow Survey	February 22, 2022
Site Visit & Instrumentation Maintenance	February 22, May 28, and September 22, 2022
Quarterly Performance Updates	March, July, and November, 2022

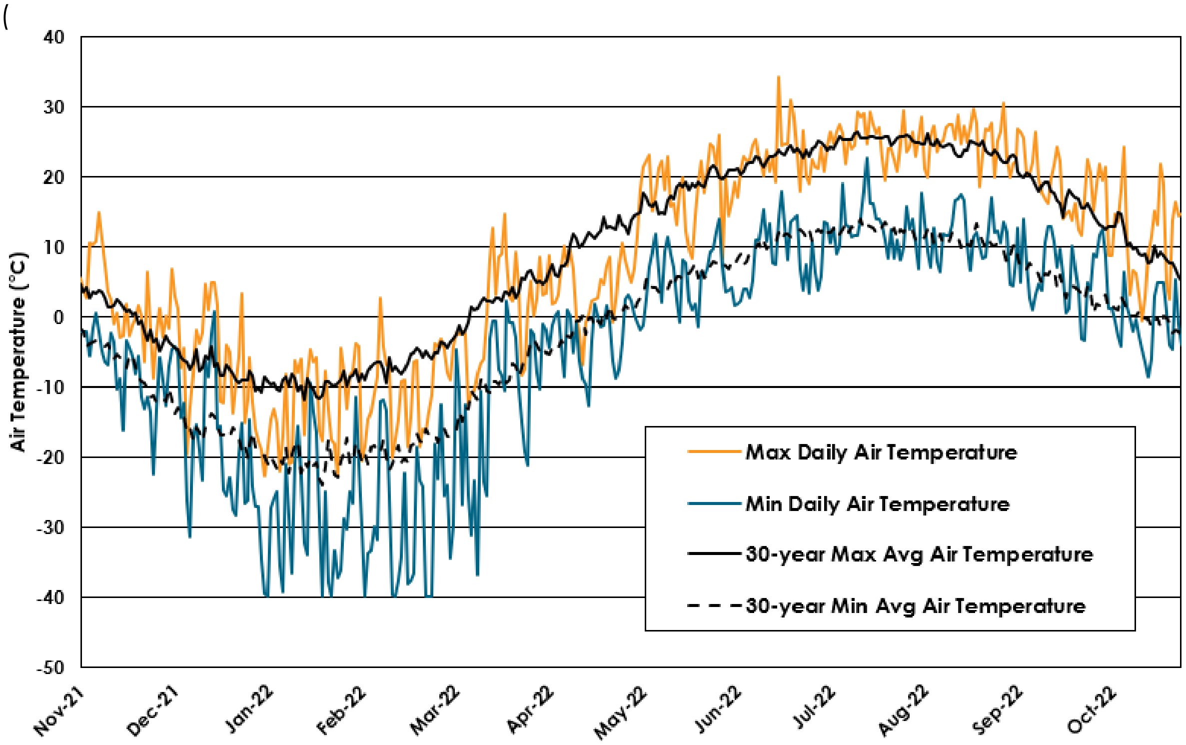
3 COVER SYSTEM PERFORMANCE MONITORING RESULTS

3.1 Meteorology

Meteorological parameters were measured at Rainy River Mine to monitor site-specific climate conditions. Rainfall, snowfall, and net radiation were measured directly on the field trial plateau while air temperature, relative humidity, and wind speed and direction were monitored at Rainy River Mine’s Barron weather station. Minor data gaps exist in the Barron station meteorological monitoring. The missing data from the Barron weather station has been backfilled by weather data from the Government of Canada weather station 6020559 located at Barwick for purposes of completing water balances.

3.1.1 Air Temperature

Annual average air temperature recorded at the Barron weather station during the monitoring period was 2.3°C (Figure **3.1**), cooler than the 30-year historical average of 3.3°C. The average winter temperature is of interest with respect to performance monitoring for the purpose of evaluating frost penetration into the cover system. Between December 2021 and March 2022, ambient air temperature ranged from -40°C to 15°C with an average temperature of -13.8°C.



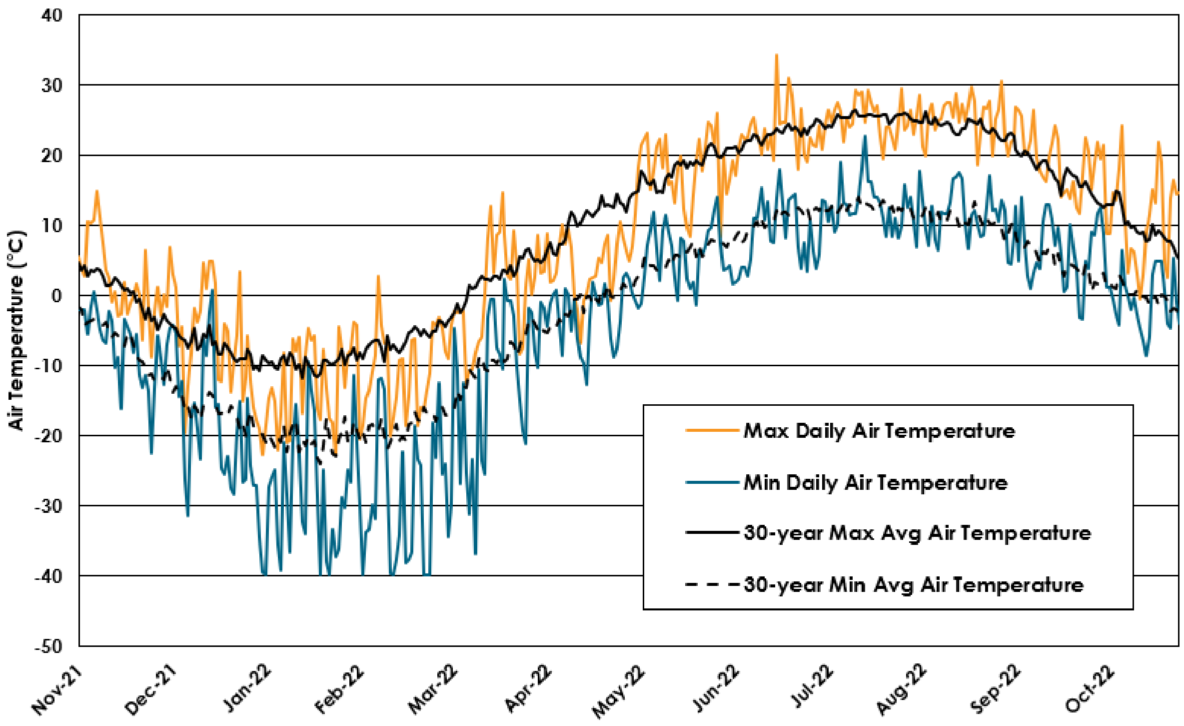


Figure 3.1: Maximum and minimum daily air temperatures recorded at Barron weather station as compared to 30-year averages.

Ambient air temperatures over the three-year monitoring period were also compared (Figure 3.2). Average air temperature recorded at the Barron weather station during the three-year monitoring period was 3.1°C, compared to the 30-year historical average of 3.3°C. The average winter temperature between December and March for each monitoring year are provided below (Table 3.1).

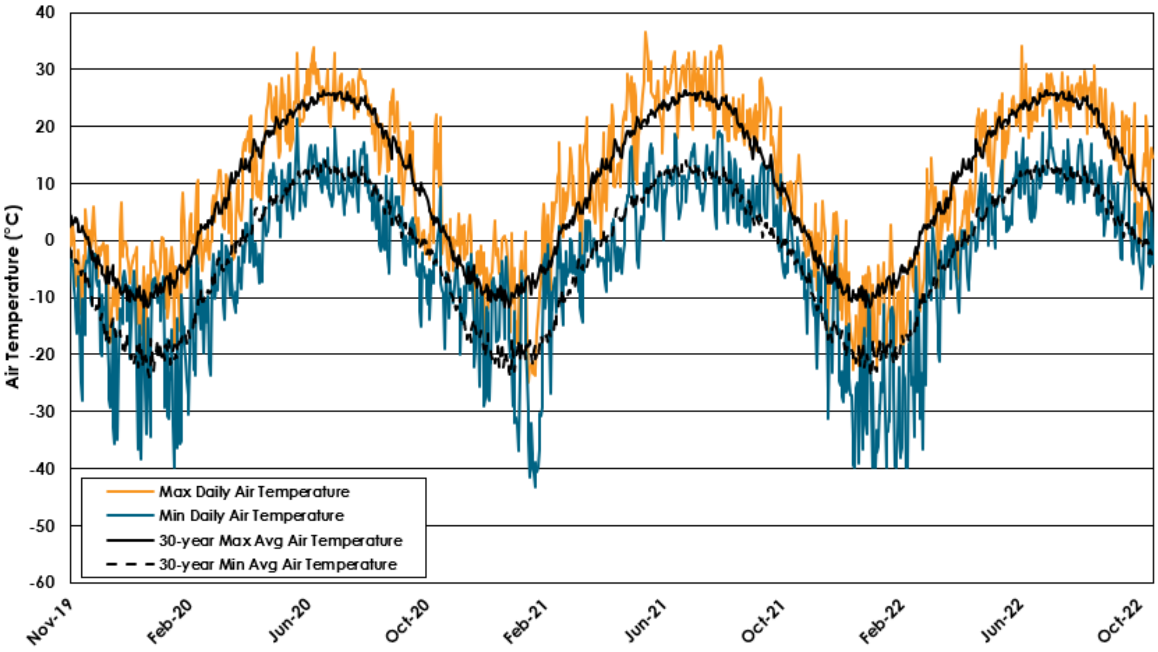


Figure 3.2: Maximum and minimum daily air temperatures over a three-year monitoring period recorded at Barron weather station as compared to 30-year averages.

Table 3.1: Ambient winter air temperature over a three-year monitoring period.

Monitoring Period	2019-2020	2020-2021	2021-2022
Lowest Winter Temperature (°C)	-39.9	-43.0	-39.9
Highest Winter Temperature (°C)	12.4	17.2	14.6
Average Winter Temperature (°C)	-10.5	-8.9	-13.8

3.1.2 Rainfall

Rainfall is collected directly on site with a Texas Electronics 525M TBRG. The TBRG installed on Trial #2 and has been collecting rainfall data since June 2018. During a site visit conducted on May 28, 2022, it was noted that the tipping bucket lid had been blown off. Due to the lid being removed, there was an observed discrepancy between the rainfall measurements recorded on Trial #2. The Trial #2 rainfall data has been amended with the EMRS Primary 1 TBRG from April 1, 2022 to May 28, 2022, when the tipping bucket lid was re-installed.

A total of 862 mm of rainfall was recorded during the monitoring period (310 mm more than the 30-year historic average). Monthly rainfall from April to October 2022 was compared to the 30-year historic average

Table **3.2**). Two relevant rainfall events occurred in November 2021, prior to freezing temperatures, and are also included below.

It was observed that April and May were substantially wetter than average, with the two months experiencing 406% and 301% more rainfall, respectively, than the 30-year historical average. The largest rainfall event occurred May 12, 2022 and was 114 mm. Rainfall activity was also considered over a three-year period (Figure 3.4).

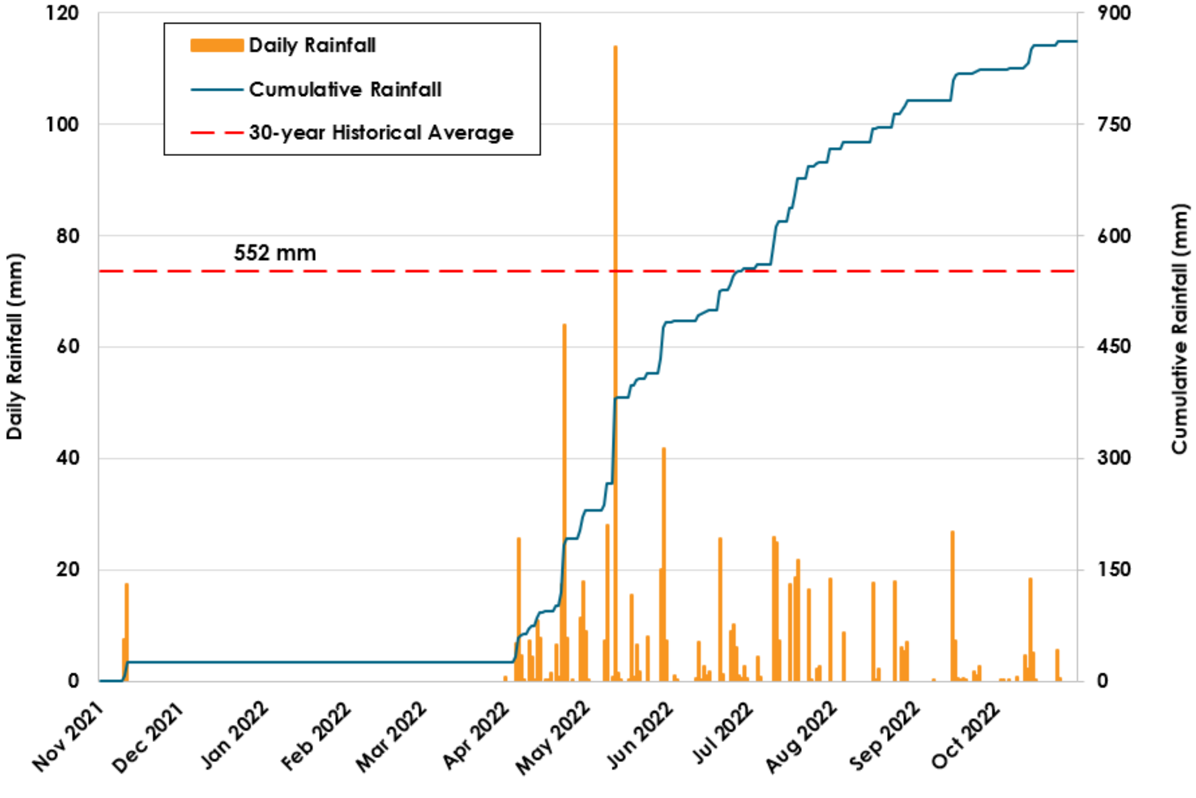


Figure 3.3: **Daily and cumulative rainfall recorded at cover system field trials.**

Table 3.2: November 2021 and April to October 2022 monthly rainfall.

Month / Year	2021-2022		30-year Average	
	Rain Days	Rainfall (mm)	Rain Days	Rainfall (mm)
November 2021	2	24.9	-	-
April 2022*	21	196.6	8	48.4
May 2022*	17	262.9	13	87.2
June 2022	17	71.9	13	107.9
July 2022	13	161.4	11	123.6
August 2022	8	65	10	78.6
September 2022	10	41.8	11	77.5
October 2022	11	37.4	11	63.6

*** Data amended with rainfall recorded at EMRS TBRG**

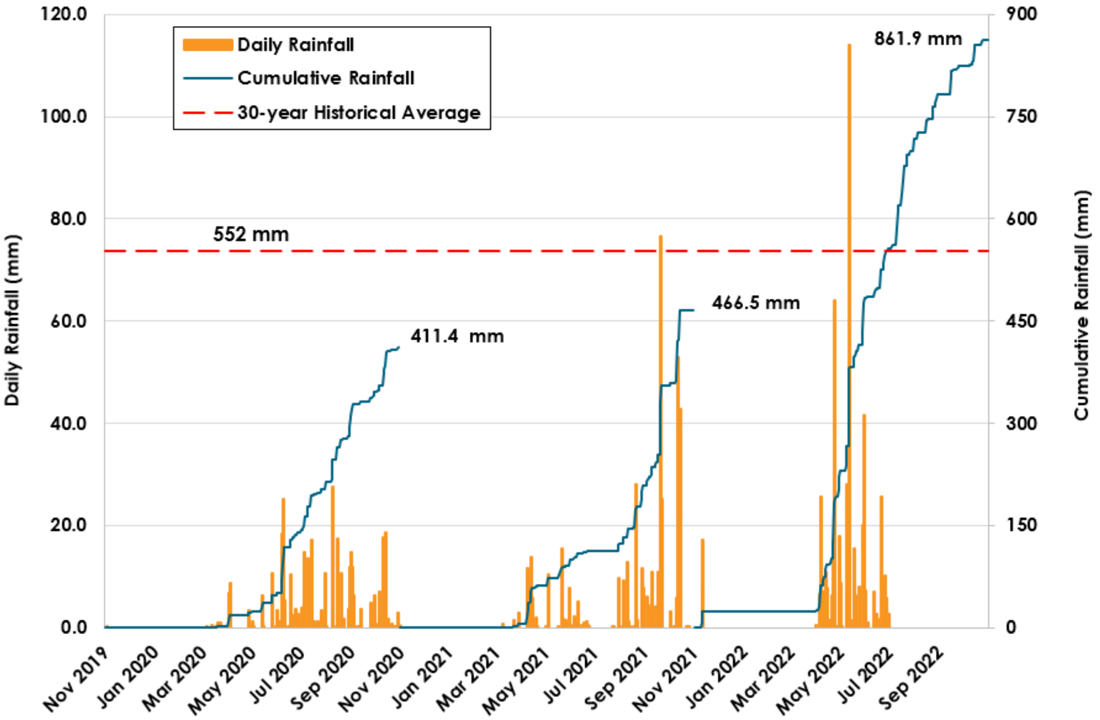


Figure 3.4: Daily and cumulative rainfall recorded at the cover trials over a three-year period.

3.1.3 Snowfall

The TBRG on the trial plateau only measures rainfall and does not directly measure snow accumulation. A snow survey was conducted by Okane to measure the depth of the snowpack on each cover system field trial on February 22, 2022. Photos of the cover trials were collected during the snow survey (Figure 3.5 through Figure **3.8**).

Figure 3.5: Plateau of Trial #1 and Trial #2 (looking East).

Figure 3.6: North slope of Trial #1 (looking West).

Figure 3.7: South slope of Trial #2 (looking East).

Figure 3.8: Snowpack on plateau.

Using the measured snow depth and weight, both density, and average snow water equivalent (SWE) for both Trial #1 and Trial #2 was calculated. Snow density was calculated to be 189 kg/m^3 and 175 kg/m^3, and SWE was calculated to be 88 mm and 78 mm, respectively, for Trial #1 and Trial #2. Average snow depth on Trial #1 and Trial #2 were measured to be 460 mm, and 430 mm, respectively.

Snow surveys were conducted on March 4, 2019, and March 3, 2020 (Table 3.3). The snow density in 2019 was estimated, whereas the density in 2020 was measured. The 2021 snow survey had no snow present, and therefore the three-year monitoring period will consist of measured data from 2019, 2020, and 2022.

Table 3.3: Three-year monitoring period snow survey results.

Measured Parameter	**2019**		**2020**		**2022**	
	Trial #1	**Trial #2**	**Trial #1**	**Trial #2**	**Trial #1**	**Trial #2**
Snow Density (kg/m^3)	100	100	150	220	189	175
Snow-water Equivalent (SWE)	51 mm	34 mm	60 mm	66 mm	88 mm	78 mm

3.1.4 Reference Evapotranspiration

Reference evapotranspiration (ET_0) was calculated using the Penman-Monteith method. The Penman-Monteith method is the sum of transpiration of water within vegetation and evaporation of free water from the surface. A hypothetical grass crop having a height of 0.12 m, 70 s m^{-1} surface resistance, and albedo of 0.23 was used (Allen *et al.* 1998). Reference evapotranspiration was calculated based on air temperature, relative humidity, and wind speed data collected at the Barron weather station and amended with the Barwick weather station. Net radiation was measured on Trial #2 cover system surface.

Monthly ET_0 was compared to monthly rainfall for March to October (Figure 3.9). A decrease in the water stored within the upper layers of the cover system is observed in months where ET_0 is greater than rainfall (e.g., March, June, August, and September). During these months there is higher potential for drying of the compacted layer resulting in a reduction in maintained degree of saturation. Similarly, periods where ET_0 is less than rainfall observe an increase in water storage and increased potential for NP into the underlying mine rock (e.g., April, May, July, and October).

When compared to the monitoring period rainfall, as well as the 30-year average, higher drying rates were only observed in June, indicating more water was added from the system than normal during all other months (Table 3.4). This is due to a cooler and wetter spring and summer. Less ET_0 was observed in 2022 compared to both 2020 and 2021. This is due to weather conditions less favourable for drying, such as cooler temperatures, less wind, less humidity, less solar insolation, or a combination of some or all these meteorological conditions.

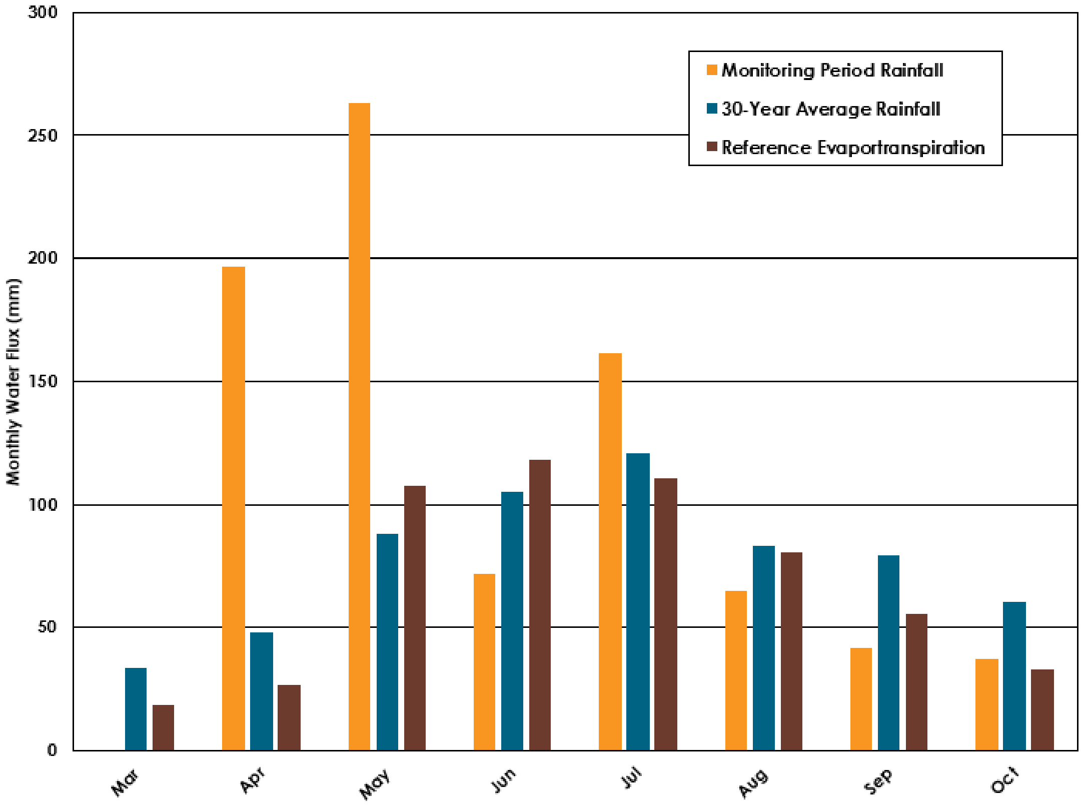


Figure 3.9: Reference evapotranspiration and total rainfall measured at Rainy River Mine from March to October 2022.

Table 3.4: Three-year summary of monthly rainfall and reference evapotranspiration.

Month	2020		2021		2022*	
	Rainfall (mm)	ET_0 (mm)	Rainfall (mm)	ET_0 (mm)	Rainfall (mm)	ET_0 (mm)
March	18.8	12.1	5.8	40.2	-	18.5
April	4.9	42.9	56.1	53.3	196.6	26.8
May	89.1	97.8	37.9	100.8	262.9	107.7
June	64.6	115.6	12.9	136.7	71.9	118.4
July	68.9	117.7	10.3	124.6	161.4	110.5
August	82.3	107.2	85.2	108.9	65	80.5
September	26.5	64.7	147.9	69.8	41.8	55.4
October	56.4	24.2	110.3	33.3	37.4	32.8
Total	**411.5**	**582.2**	**466.4**	**667.7**	**837**	**550.7**

***November rainfall not included in total**

3.2 Cover System Temperature Profiles

Soil temperature was monitored over the entire cover system profile of Trial #1 and Trial #2 to observe freeze-thaw cycling and the depth of frost penetration. The largest implication of freeze-thaw cycles on cover system performance is potential changes to physical properties of the material, such as altering the hydraulic conductivity. Freezing temperatures were observed in both cover system configurations during the monitoring period. Trial #1 first observed freezing temperatures beginning February 18, 2022 and reach a maximum freezing depth of 10 cm (Figure 3.10). Freezing temperatures in Trial #2 was first observed December 26, 2021 and reached a maximum freezing depth of 110 cm (Figure 3.11).

Trial #2 was generally more sensitive to temperature throughout the monitoring period. Trial #2 saw cooler temperatures throughout the winter, and warmer temperatures in the summer, compared to Trial #1. Although freezing depths were recorded at 110 cm at Trial #2, minimum temperatures were only slightly below 0 °C. A minimum temperature of -1.0 °C was recorded at 30 cm, and -0.5 °C at both the 90 cm and 110 cm sensors. Average temperatures throughout the monitoring period were similar enough between Trial #1 and Trial #2 to identify any discrepancies that may influence temperature. Vegetation is reasonably established on both Trial #1 and Trial #2 and therefore had minimal differentiating influencing factors on temperature. A summary of freezing depths and dates is also provided for the three-year monitoring period (Table 3.5).

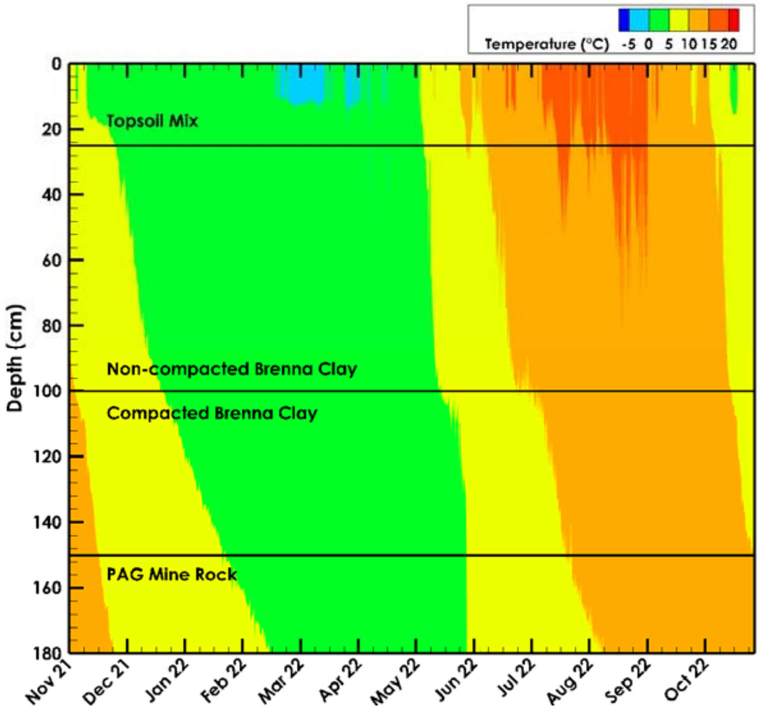


Figure 3.10: Soil temperature profile measured at Trial #1 Primary Nest during the monitoring period.

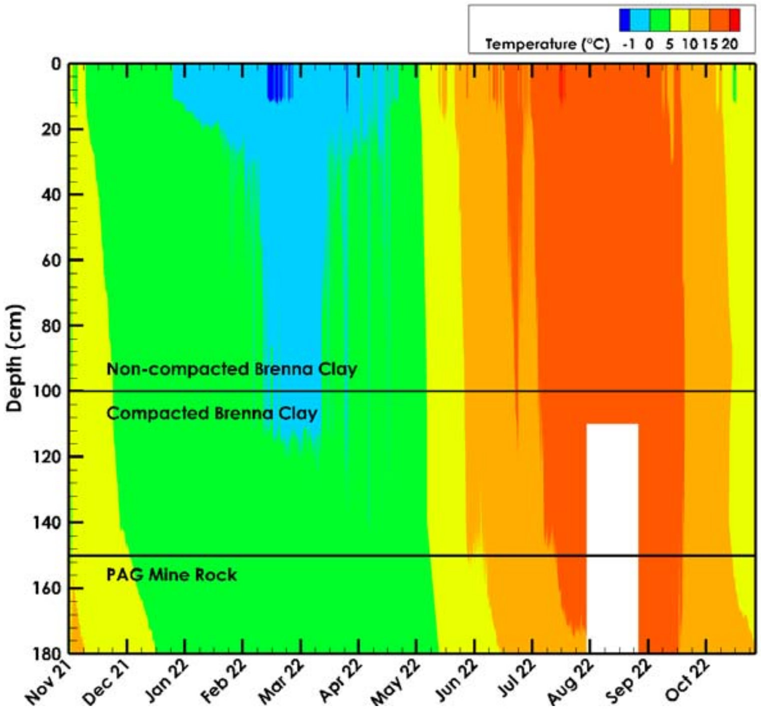


Figure 3.11: Soil temperature profile measured at Trial #2 Primary Nest during the monitoring period (white areas indicate periods of missing data).

Table 3.5: Three-year summary of freezing depths and dates.

Measure Parameter	2019-2020		2020-2021		2021-2022	
	Trial #1	Trial #2	Trial #1	Trial #2	Trial #1	Trial #2
Date of freezing	Dec 9, 2019	Dec 17, 2019	Dec 15, 2020	Feb 6, 2021	Feb 18, 2022	Dec 26, 2021
Depth of freezing (cm)	30	10	30	20	30	110

Temperature within the PAG mine rock was measured over a three-year period. Annual temperatures within the mine rock vary between 2°C and 12°C for Trial #1 (Figure 3.12) and 1°C and 16°C for Trial #2 (Figure 3.13). Mine rock temperatures follow similar atmospheric heating and cooling patterns as the cover system. There is no clear additional source of heating within the mine rock mass.

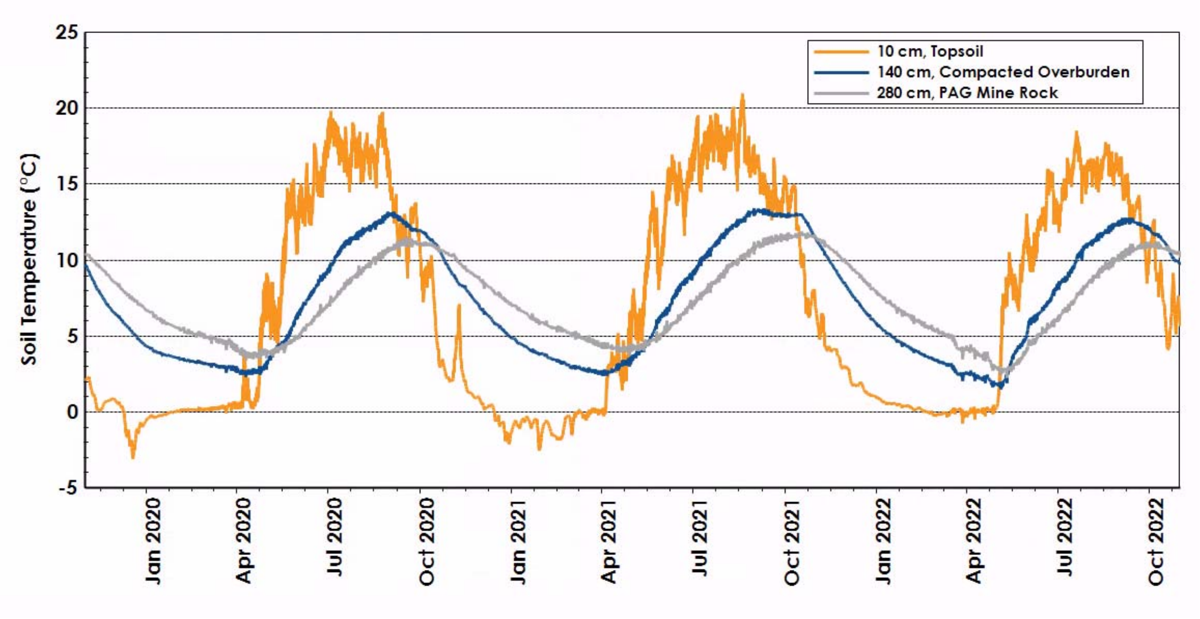


Figure 3.12: Trial #1 PAG mine rock temperatures over a three-year monitoring period.

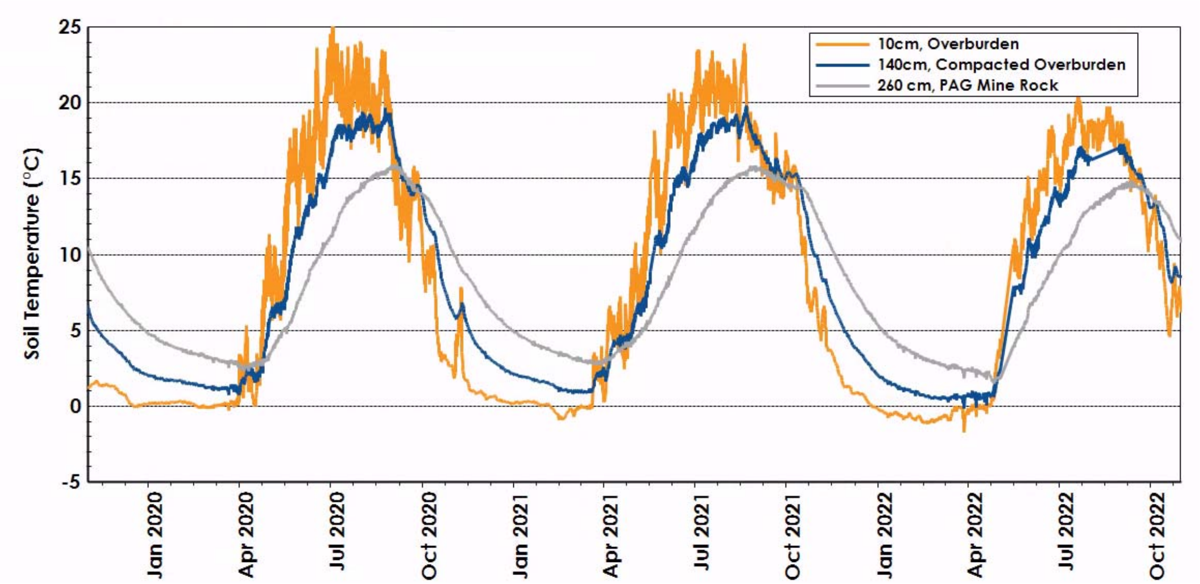


Figure 3.13: Trial #2 PAG mine rock temperatures over a three-year monitoring period.

3.3 Cover System Water Dynamics

Volumetric water content and matric suction were measured throughout each cover system profile. Volumetric water content and matric suction measurements can be further analyzed to investigate performance and water dynamics of the cover system. This section presents the results of the data analysis, while direct *in situ* measurements are presented in Appendix B. The top of each cover system was selected as origin datum for all instrumentation depths.

3.3.1 Degree of Saturation

Volumetric water content was measured throughout each cover system profile to observe changes in the degree of saturation of the cover system material. To successfully mitigate the ingress of oxygen into the underlying mine rock, a material must remain at or near saturated levels. As the degree of saturation exceeds 80%, the diffusion coefficient typically decreases by several orders of magnitude. A general guideline suggests that maintaining a consistent degree of saturation of 85% or greater within a layer will effectively limit the amount of oxygen movement by diffusion (Aachib *et al.* 2004).

Water content data shows that the compacted clay layer in both cover system profiles maintained a high degree of saturation throughout the monitoring period, having an annual average degree of saturation of 97%, and 95%, for Trial #1 and Trial #2, respectively (Table 3.6). The degree of saturation maintained in the cover system demonstrates that the compacted clay layer is retaining sufficient pore-water to attenuate oxygen transport. The

2020-2021 monitoring period observed the degree of saturation of the compacted layer drop below 90% throughout the dry, warm summer. Water content of the compacted layer recovered substantially in 2022 during the wetter Spring/Summer months and remained primarily above 90% for the duration of the monitoring period. It can be determined from monitoring results that the objective of mitigating oxygen ingress is effectively achieved through the maintenance of an adequate degree of saturation in both the compacted and noncompacted layers throughout the monitoring period. Estimated oxygen diffusion modelling is further quantified and discussed in Section 3.5.

Table 3.6: Average degree of saturation of cover system layers.

	Noncompacted Clay		Compacted Clay		
	0 – 50 cm	50 – 100 cm	Maximum	Minimum	Average
Trial #1 Primary Nest	79%	91%	100%	91%	97%
Trial #2 Primary Nest	86%	91%	100%	83%	95%

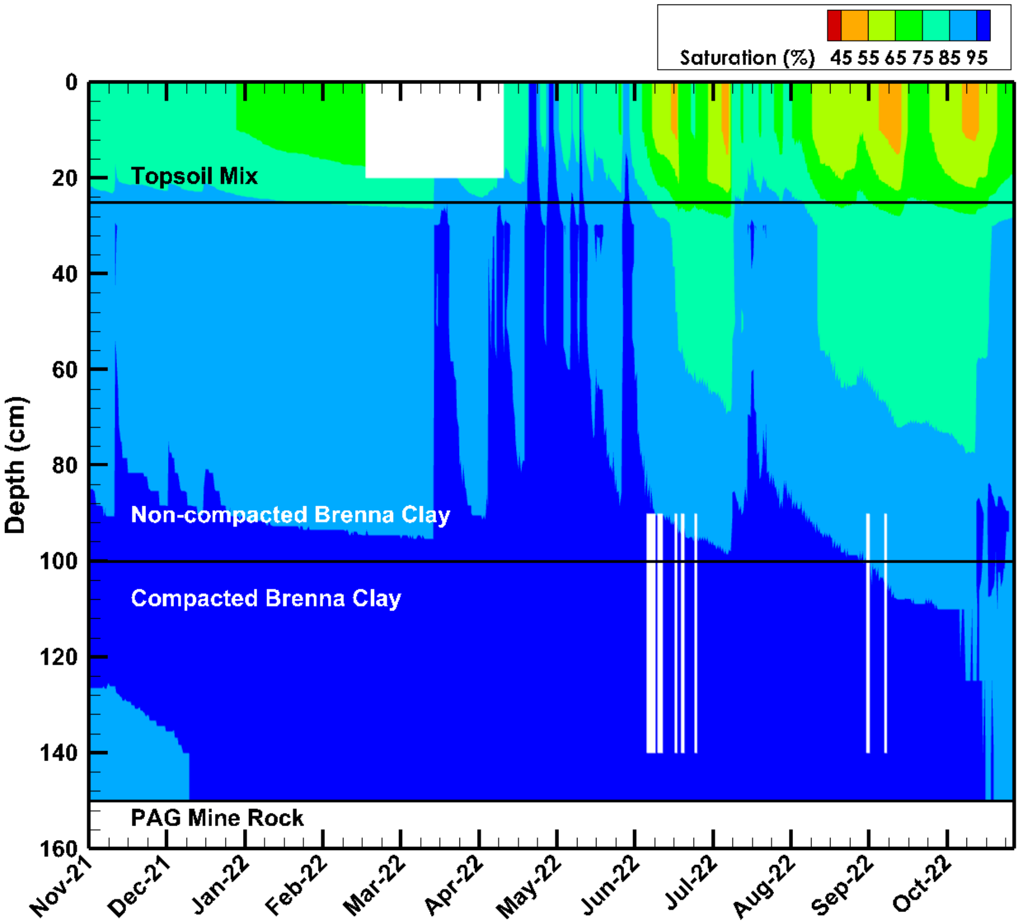


Figure 3.14: Change in degree of saturation at Trial #1 Primary Nest (white areas indicate periods of freezing temperatures or missing data).

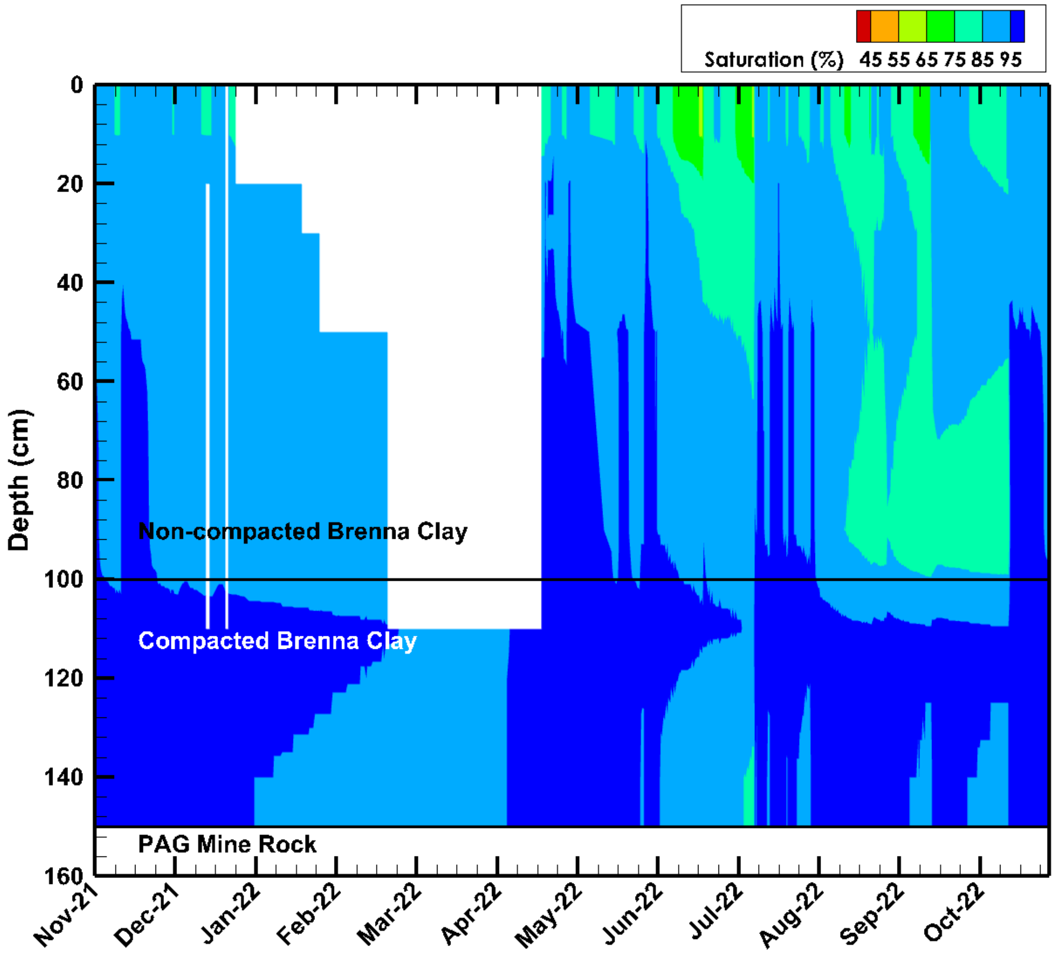


Figure 3.15: Change in degree of saturation at Trial #2 Primary Nest (white areas indicate periods of freezing temperatures or missing data).

The three-year monitoring period was also analyzed for degree of saturation and the results of Trial #1 (Figure 3.16) and Trial #2 (Figure 3.17) primary nests are provided below. The 2020-2021 monitoring period experienced the lowest degree of saturation throughout the entire cover system for both Trial #1 and Trial #2 when compared to the 2019-2020 or 2021-2022 monitoring years. This is attributed to the lack of precipitation throughout the summer months, which allowed the drying front to extend. Saturation increased in the compacted clay layer during Autumn 2021 and continued to remain primarily above 95% for the duration of the 2021-2022 monitoring period. Increased rainfall during Autumn 2021 and throughout Spring and Summer of 2022 contributed to an increased degree of saturation throughout the compacted layer at both cover trials (Okane, 2022).

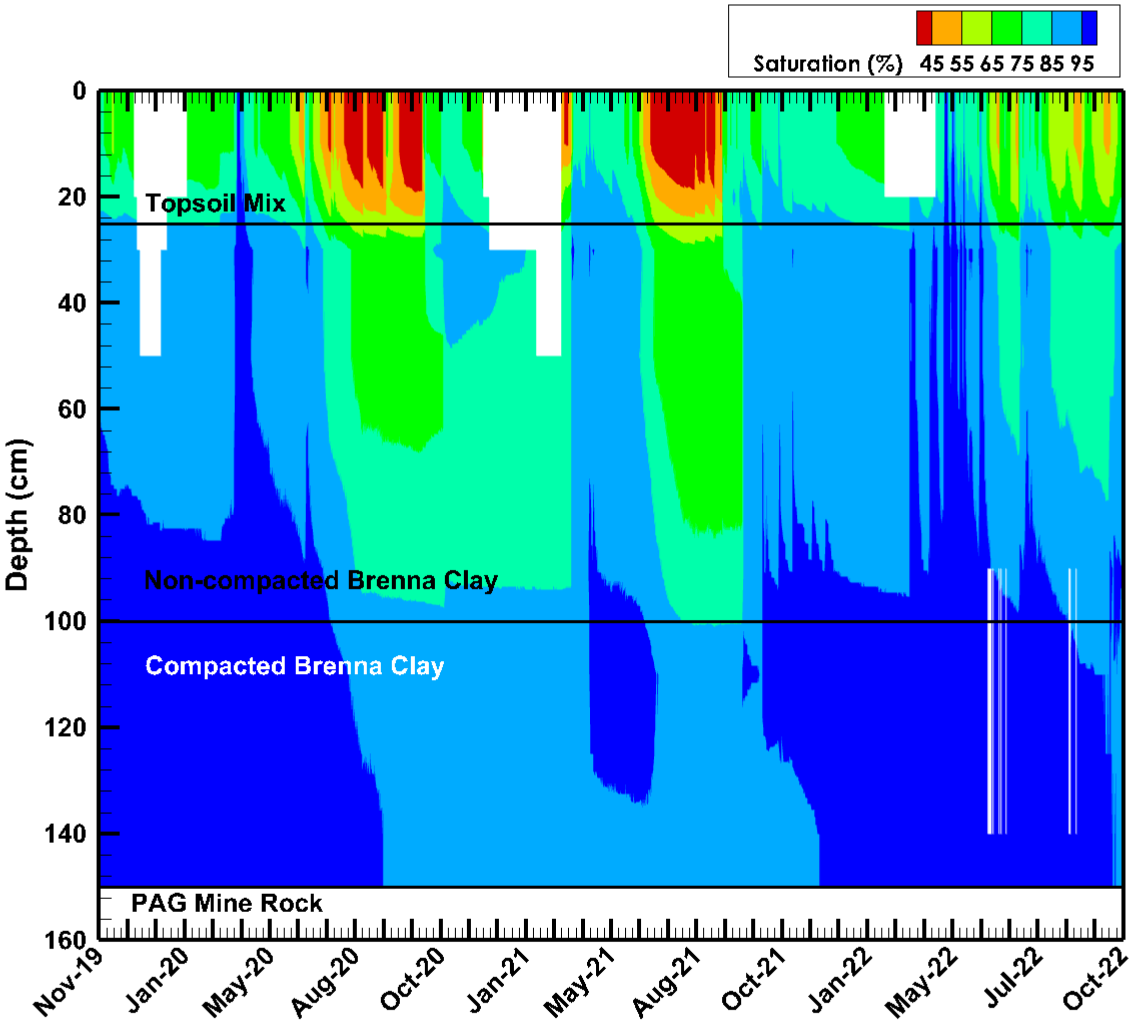


Figure 3.16: Change in degree of saturation over a three-year monitoring period at Trial #1 Primary Nest (white areas indicate periods of freezing temperatures or missing data).

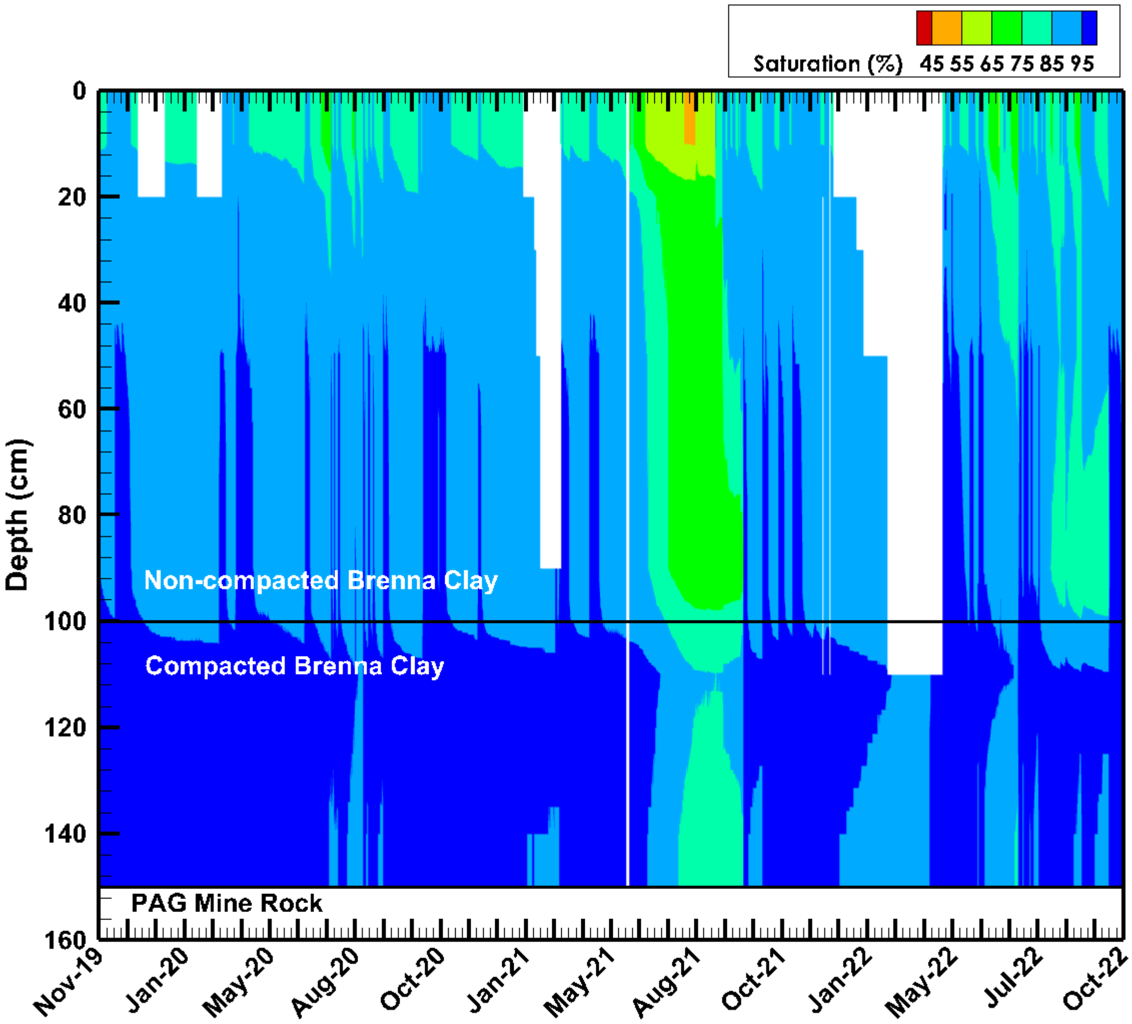


Figure 3.17: Change in degree of saturation over a three-year monitoring period at Trial #2 Primary Nest (white areas indicate periods of freezing temperatures or missing data).

3.3.2 Summary of Matric Suction Data

Matric suction sensors were installed in each cover system profile to measure negative pore-water pressure (suction). In unsaturated soils, suction provides an indication of the affinity of a soil for water, expressed as an energy potential. Measurements of less than 10 kPa are outside the installed sensor measurement range as the resolution of measurements in this range cannot be specifically measured and can be considered as any value between 0 to 10 kPa. Suction values greater than about 400 kPa are calculated from laboratory calibrations completed with salt brines generating osmotic suction. Calibration of individual sensors in this suction range can be challenging and therefore values greater than 400 kPa can be considered as high suctions but the trend in estimated suction value is likely more valuable than the absolute value.

Overall, Trial #2 (Figure 3.19) observed slightly higher suction values deeper within the cover system than Trial #1 (Figure 3.18) (suction values measured >250 kPa within the compacted layer). Suction was comparable throughout the monitoring period between Trial #1 and Trial #2, with Trial #2 experiencing higher suctions at depths up to 50 cm during June and July 2022. Higher suction values in the non compacted layer can indicate the established vegetations ability to translocate water out of the soil matrix during warmer and drier months. Low suction values coupled with high saturations in the compacted clay layer indicate a high permanent wilting point (PWP) and that even water is unable to be pulled from the soil matrix of the compacted layer.

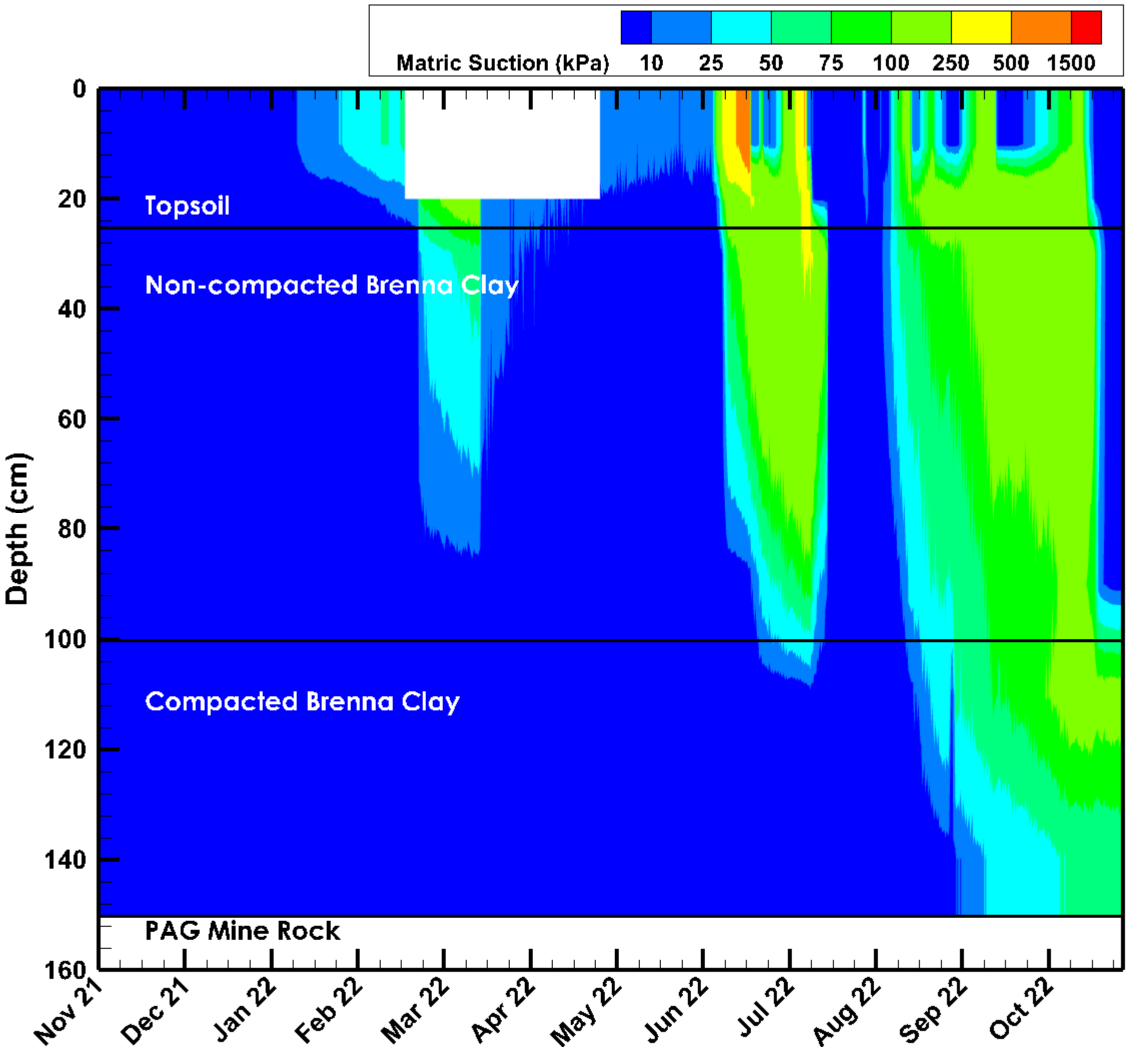


Figure 3.18: Matric suction profile measured at Trial #1 Primary Nest (white areas indicate periods of freezing temperatures or missing data).

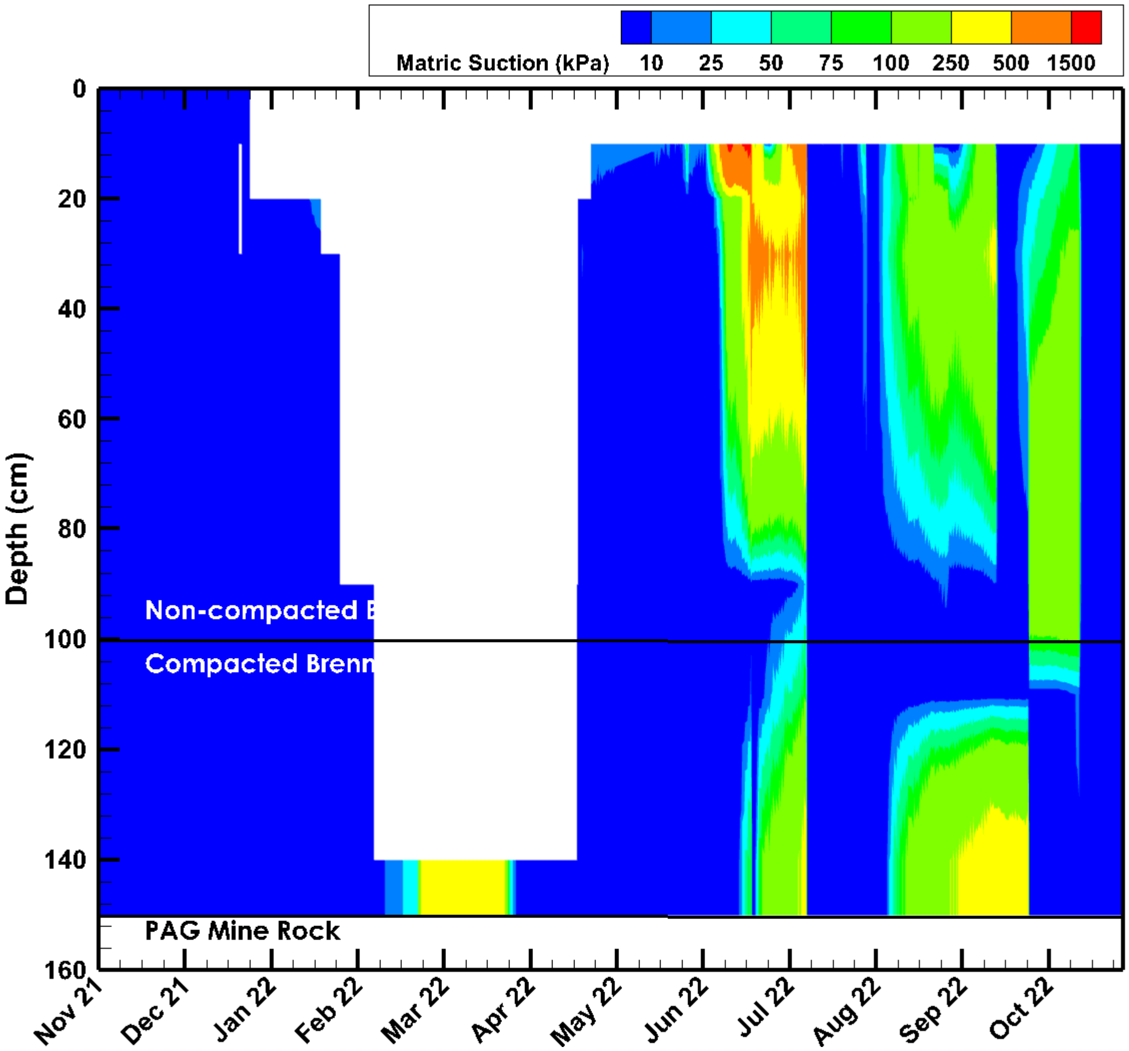


Figure 3.19: Matric suction profile measured at Trial #2 Primary Nest (white areas indicate periods of freezing temperatures or missing data).

The three-year monitoring period analysis of Trial #1 (Figure 3.20) and Trial #2 (Figure 3.21) is provided below. The 2020-2021 monitoring year showed the highest matric suctions of all three years in both trials. This was expected due to the lack of rainfall and warm temperatures during the 2021 Spring/Summer. Rainfall occurring in Fall 2021, snowfall from Winter of 2021/2022, and rainfall from Spring/Summer 2022 all worked to reduce and hold suction at a decreased value. Although the compacted layer observed some periods of high suction throughout the three-year monitoring period, the compacted layer was still able to maintain a sufficient degree of saturation, as outlined in Section 3.3.1.

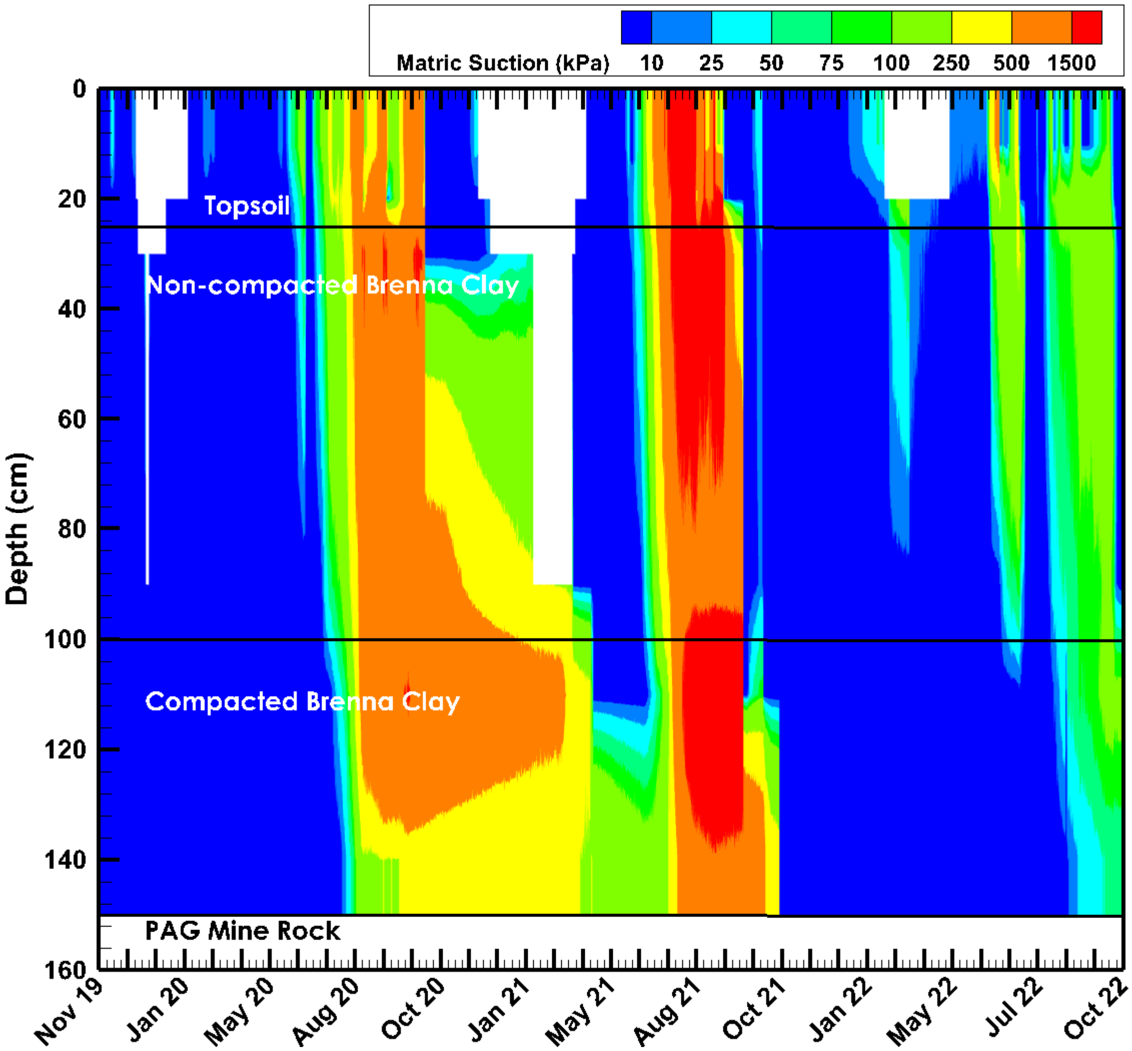


Figure 3.20: Matric suction profile measured at Trial #1 Primary Nest over a three-year monitoring period (white areas indicate periods of freezing temperatures or missing data).

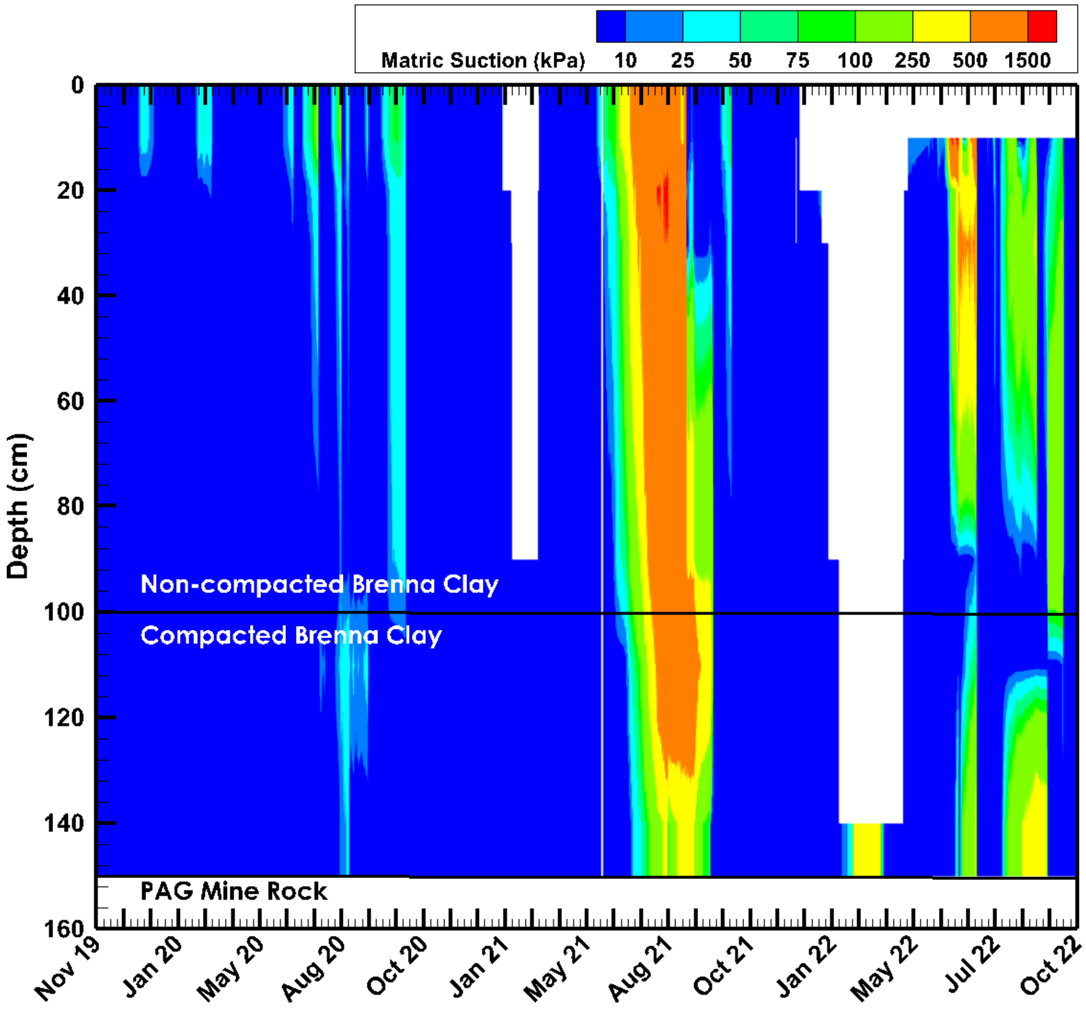


Figure 3.21: Matric suction profile measured at Trial #2 Primary Nest over a three-year monitoring period (white areas indicate periods of freezing temperatures or missing data).

3.3.3 Total Water Storage

The total water storage within the cover system profiles was determined by using field data to produce water retention curves (WRCs) from combined volumetric water content and suction data during the monitoring period. From the WRCs, the water content at which field capacity (FC) is reached can be determined. The FC is the volume of water stored in a soil matrix after the soil is allowed to drain from saturation freely under gravity (with no evaporative loss) and typically corresponds to the water content at suction values of 33 kPa for fine grained soils. Inputs of water above FC fill the largest pores, which then quickly drain under gravity due to an inability of large macropores to exert sufficient tension to retain the water. The total storage of water below field capacity within the cover system was calculated to determine the capacity to store new precipitation within the soil matrix. The total available storage in the cover system was approximately 550 mm.

Volumetric water content data was used to calculate the total measured water storage within each primary nest profile. A total water storage profile was created from sectioning the cover system into representative layers, with each layer having a sensor at its centre. For sensors placed at 10 cm, 20 cm, and 30 cm the representative layers are 0 to 15 cm and 15 to 25 cm. During periods where the measured storage is less than the total available storage, the soil has room to hold more water within the profile. Conversely, periods where the measured storage volume is greater than the total available storage the profile is not able to store new precipitation and infiltrated water will produce larger NP events.

Examination of measured water storage within the cover system profiles demonstrate the effect vegetation has on the capacity of the cover system to store and release water within the upper meter. Trial #2 had less water stored within the soil matrix in March 2022, as compared to Trial #1. This allowed for incoming precipitation to be stored more effectively, which assists in reducing overall NP into the underlying mine rock. Trial #1 and Trial #2 stored water capacity showed similar trends from April to September 2022 (Figure 3.22). The decrease in storage during warmer and drier months, such as June and August 2022, allows for new precipitation to be stored within the soil profile and not infiltrate to the underlying mine rock. If vegetation diminishes on the clay overburden, the cover system will not be as effective as a store-and-release system. Currently, both Trial #1 and Trial #2 are following trends consistent with the field capacity, demonstrating effective store and release capabilities, while maintaining a high degree of saturation.

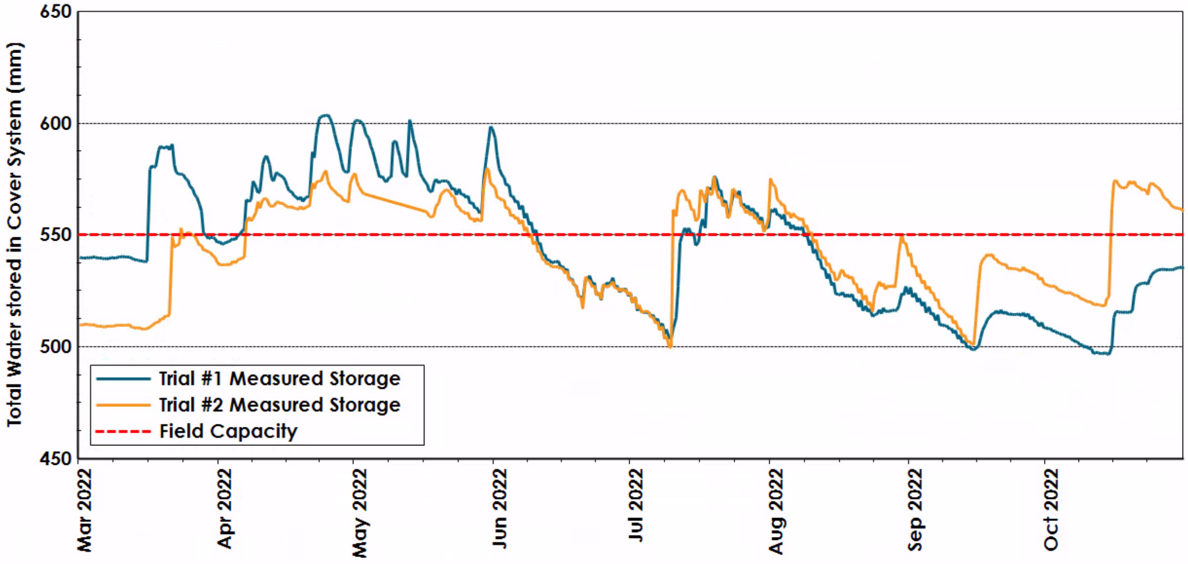


Figure 3.22: Measured storage vs. cover system field capacity.

The three-year monitoring period between March 2020 and October 2022 was also evaluated below (Figure 3.23).

In the Summer of 2020, the measured storage at Trial #1 dropped approximately 100 mm below field capacity, whereas Trial #2 remained near field capacity. This difference was largely due to a discrepancy in vegetation differences between the cover systems. During the Summer of 2021, measured storage at both Trial #1 and Trial #2 experienced storage losses of more than 100 mm below field capacity. Although vegetation was similar between both cover trials, storage losses were attributed to a lack of precipitation during the monitoring period. During the Summer of 2022, storage for both Trial #1 and Trial #2 were comparable, fluctuating both above and below field capacity. Both Trials demonstrated store and release capabilities, while remaining at or near field capacity for water storage.

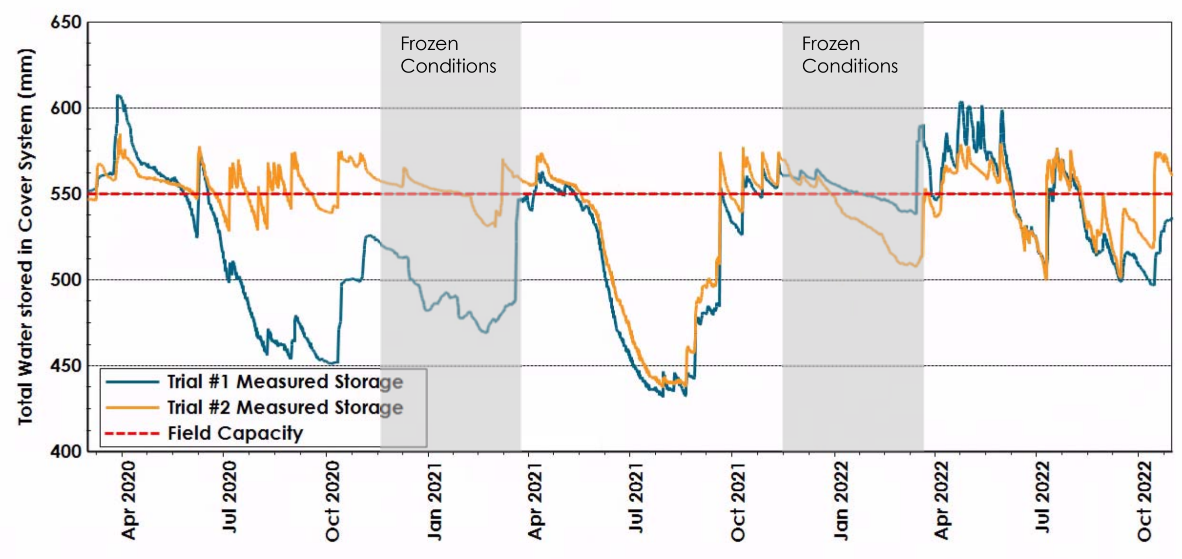


Figure 3.23: 3-year period of measured storage vs. cover system field capacity.

3.4 Water Balance

3.4.1 Discussion of Water Balance Inputs

A numerical model was utilized for water balance estimation that uses inputs of both meteorological data and soil monitoring data (suction gradients, VWC, measured storage) and estimates the remaining water balance components to balance the equation (Equation 1). The use of this software increases accuracy and consistency of water balances. Water balances were developed for each primary station to estimate the volume of water percolating through the cover system to the underlying mine rock.

$$PPT = SB + RO + ET_0 + NP + \Delta S + ITF \qquad [1]$$

where:

PPT = precipitation (rainfall plus snow water equivalent)

SB = sublimation (assumed to be zero)

RO = runoff;

ET_0 = evapotranspiration;

NP = net percolation;

ΔS = change in water storage within the cover system profile; and

ITF = interflow (assumed to be zero)

Precipitation was measured at site with a TBRG to measure rainfall. Daily spring melt was estimated using a combination of data collected from the February 22, 2022 snow survey, and the degree-day method with a degree day coefficient of 2.74 mm/degree-day °C and an estimated snow ripening period of seven days (USDA, 2004).

Runoff is not measured at the PAG field cover trials but was estimated during spring freshet and large rainfall events based on Okane's experience at sites where runoff is monitored. At similar sites, to produce a runoff event of 1 mm, rainfall events of at least 10 mm were required in periods of ~24 hours or less. Based on these findings, runoff events were estimated for the monitoring period as approximately 10% of daily rainfall totals exceeding 10 mm during spring and summer months. This may vary depending on the frequency and intensity of daily rainfall events. Snowmelt is also considered to be runoff when ground conditions are still frozen.

The primary purpose of the water balance is to estimate NP rates which was estimated based on changes in water storage in the compacted clay layer, suction gradients, and conservative flow limitations of a barrier layer (hydraulic conductivity equal to or lesser than 10^{-7} cm/s).

The water balance is an indirect method of calculating NP. Therefore, the uncertainty associated with the individual components of the water balance are compounded when estimating NP. Water balance uncertainties are constrained to the extent possible using engineering judgement. The estimated NP rates and patterns determined using the water balance method generally support the conceptual model, and as such support the suitability of the water balance method for this site. Numerical modelling methods were used in development of the water balance

The numerical model uses soil parameters such as hydraulic conductivity and porosity to improve accuracy in estimating runoff and NP. Manual adjustments are also completed based on site specific conditions that the simulation may not account for, such as hard panning of the topsoil or site topography, which help further improve the accuracy of the water balance results. The numerical simulation software utilizes the Soil Conservation Science (SCS) curve number (CN) to increase the accuracy of runoff estimation. The CN is determined through defining the Hydrologic Soil Group (HSG), cover description, and hydrologic condition. HSG Group C was chosen based on the results of the permeability testing completed on the compacted clay at the East Mine Rock Stockpile. An HSG Group C classification means that the soil has a slow infiltration rate. The other parameter used in the simulation is the vegetation cover type, which was chosen to be brush in good condition (>75% of the surface is covered), based on site observations during the various 2022 site visits. The vegetation cover at both Trial #1 and Trial #2 resulted in a curve number for the hydrologic soil group of 70 (USACE et.al.,2022).

3.4.2 Water Balance Results

Calculated change in storage matched measured change in storage for Trial #1 (

Figure **3.24**) and Trial #2 (Figure 3.25) water balances. NP in Trial #1 was 119 mm (12.5% of annual precipitation). This NP follows the performance outlined in the conceptual model and produced low NP rates according to the INAP Guidance Document for the given climate region (INAP, 2017). NP in Trial #2 was 130 mm (14% of the annual precipitation) (

Table **3.7**) resulting in low NP rates. Runoff for Trial #1 and Trial #2 was 41% and 39.5%, respectively; higher than the conceptual model predictions of 10-20%. Excess rainfall (310 mm more than the 30-year historic average) resulted in high runoff rates for the season. Due to the low NP as a result of the CCL barrier layer, minimal storage changes, and high evapotranspiration relative to potential evapotranspiration, runoff values were increased.

Table 3.7: Water balance components.

	ET_0 mm (% PPT)	Runoff mm (% PPT)	Net Percolation mm (% PPT)	Change in Storage mm (% PPT)
Conceptual Model	50 – 70%	10 – 20%	5 – 15%	N/A
Trial #1	468 (49%)	388 (41%)	119 (12.5%)	-25 (-2.5%)
Trial #2	441 (47%)	372 (39.5%)	130 (14%)	-4 (-0.5%)

PPT = Annual Precipitation

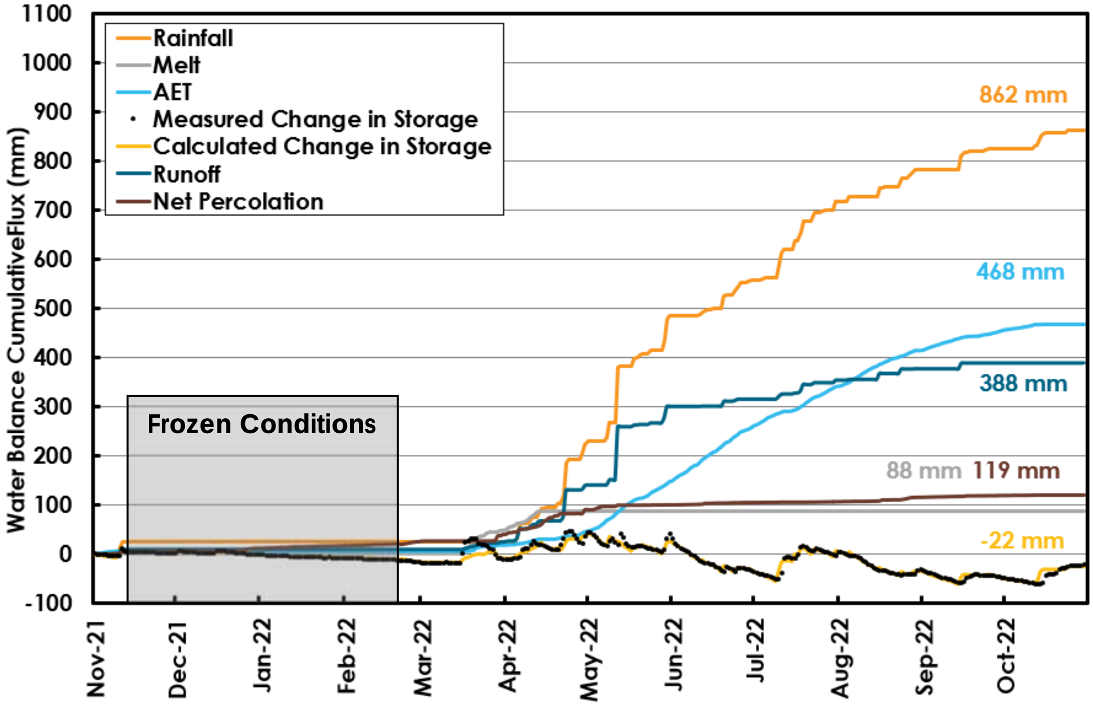


Figure 3.24: Cumulative water balance fluxes for Trial #1 for the monitoring period.

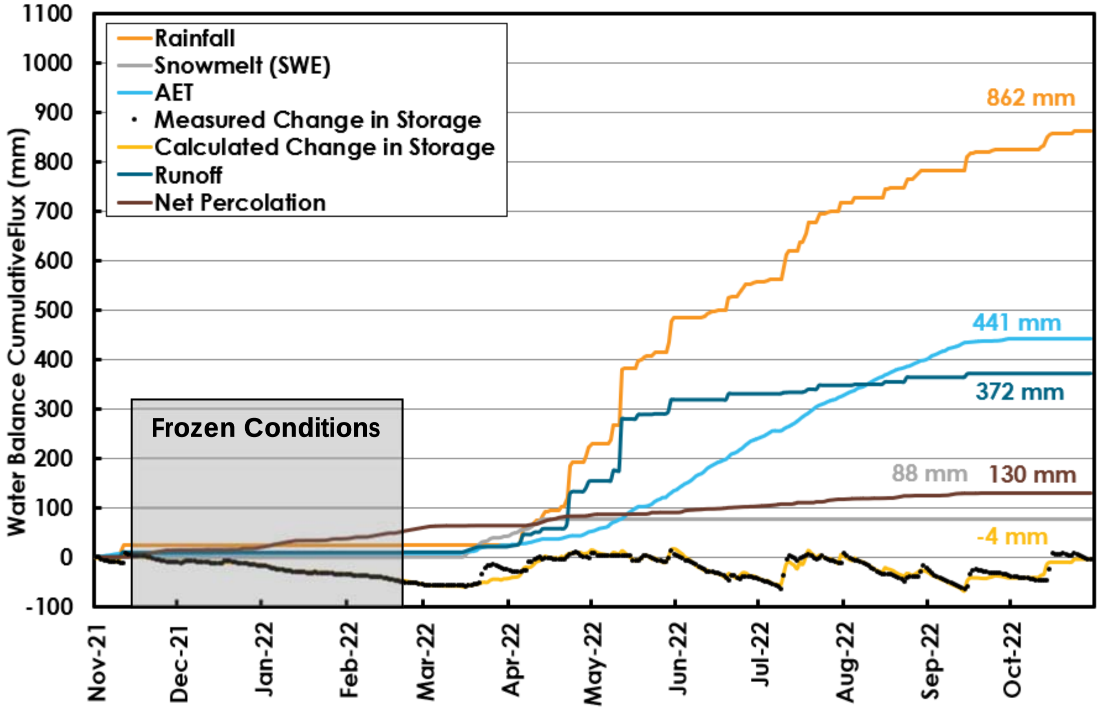


Figure 3.25: Cumulative water balance fluxes for Trial #2 for the monitoring period.

The results of the 2019-2020, and 2020-2021 water balance are provided for comparison (Table 3.8). Water balance modelling was refined for the 2021-2022 water year with the use of a numerical modelling software. Most notable is the increase in runoff as a percentage of precipitation during the 2021-2022 monitoring period. As mentioned, this runoff value is inflated due to the excess rainfall measured during the monitoring period. It is expected that the percentage of precipitation will increase for evapotranspiration under more average rainfall conditions, as the cover trials will experience less runoff.

Table 3.8: Water balance components over the three-year monitoring period.

Monitoring period		ET_0 mm (% PPT)	Runoff mm (% PPT)	Net Percolation mm (% PPT)	Change in Storage mm (% PPT)
	Conceptual Model	50 – 70%	10 – 20%	5 – 15%	N/A
2019-2020	Trial #1	378 (80%)	114 (24%)	43 (9%)	-
	Trial #2	287 (60%)	113 (23%)	75 (16%)	-
2020-2021	Trial #1	239 (49%)	122 (25%)	75 (15%)	60 (13%)
	Trial #2	240 (48%)	139 (28%)	120 (24%)	-2 (-0.4%)
2021-2022	Trial #1	468 (49%)	388 (41%)	119 (12.5%)	-25 (-2.5%)
	Trial #2	441 (47%)	372 (39.5%)	130 (14%)	-4 (-0.5%)

3.5 Estimated Oxygen Ingress

Automated oxygen sensors located in the underlying mine rock were monitored to observe the ingress and consumption of oxygen. Fluctuation in oxygen concentrations have been observed since the construction of the cover trials. These fluctuations have been attributed to insufficient thickness of the clay key surrounding the field trials allowing oxygen to bypass the cover system through advection. Due to this ingress pathway, monitoring oxygen concentrations is not a definitive approach to measure the ability of the cover system to mitigate oxygen ingress.

To quantitatively estimate oxygen diffusion into the mine rock through the cover materials, a Monte Carlo simulation has been completed separately for both trials. The simulation used the degree of saturation as provided in Section 3.3.1, and varied the following material properties as a sensitivity analysis to estimate both best- and worst-case scenarios:

- Dry density of CBC between 1,600 kg/m^3 and 1,700 kg/m^3;
- Dry density of non-compacted clay overburden between 1,450 kg/m^3 and 1,550 kg/m^3;

- Dry density of topsoil between 1,400 kg/m^3 and 1,500 kg/m^3 (Trial #1 only); and
- Initial oxidization rate (IOR) of the mine rock between 1x10^{-11} kg/tonne/s and 1x10^{-7} kg/tonne/s.

The simulation was repeated 1,000 times, with the above parameters varied for each simulation. The results of the simulation for Trial #1 show that the median results predict approximately 1 mol of oxygen had diffused into the mine rock over the monitoring period (Figure 3.24). Approximately 2 mol of oxygen was predicted to ingress during the 2020-2021 monitoring period, due to drier conditions observed in the CCL. The 99th percentile oxygen ingress estimation was approximately 2.5 mol over the monitoring period. The results for Trial #2 indicate over 1.4 mol of oxygen had diffused into the mine rock over the monitoring period, with approximately 2.8 mol of oxygen diffusion occurring in the 99th percentile estimate (Figure 3.27). Trial #1 and #2 both shows an increase in oxygen diffusion rates after June 2022, caused by the decrease in the degree of saturation where little rainfall was recorded.

The results of the modelling indicate a very low oxygen flux through the cover system (1 to 5 mol/m^2/year) according to the INAP Guidance Document (INAP, 2017). The oxygen flux through the cover system was able to stay within conceptual performance expectations, even during drier periods.

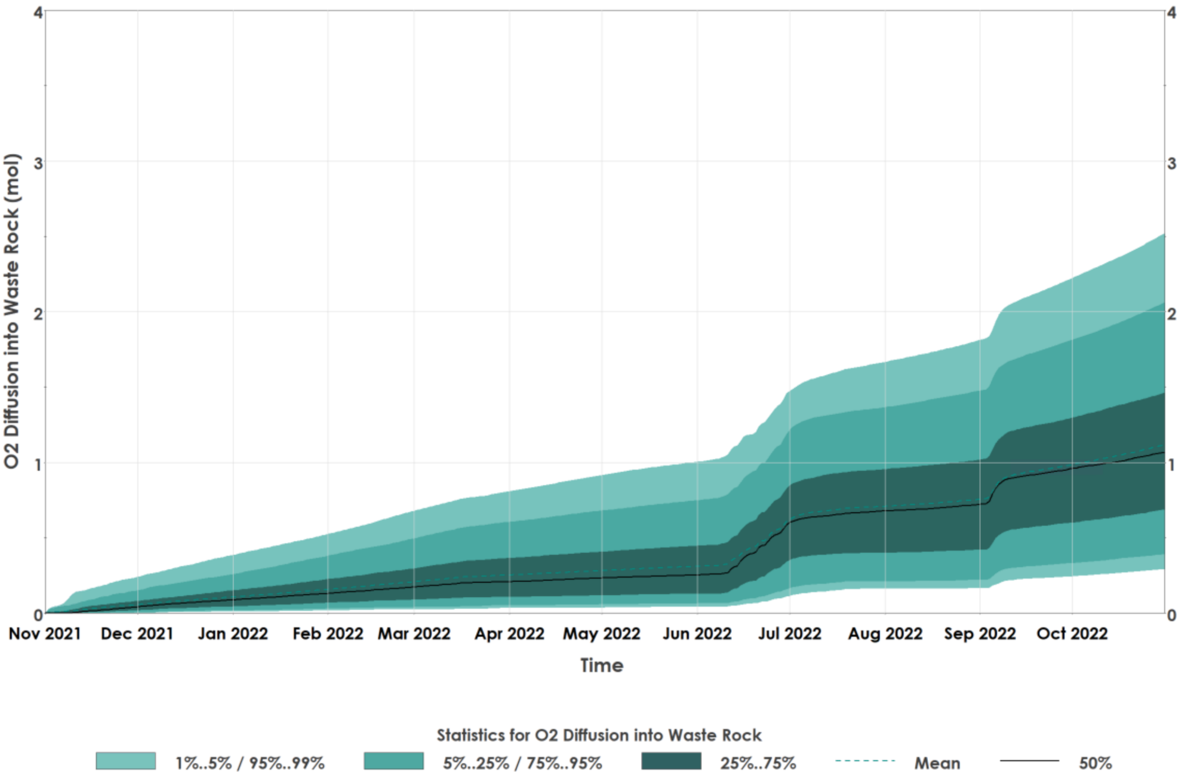


Figure 3.26: Oxygen diffusion simulation through cover materials on Trial #1 over a three-year monitoring period.

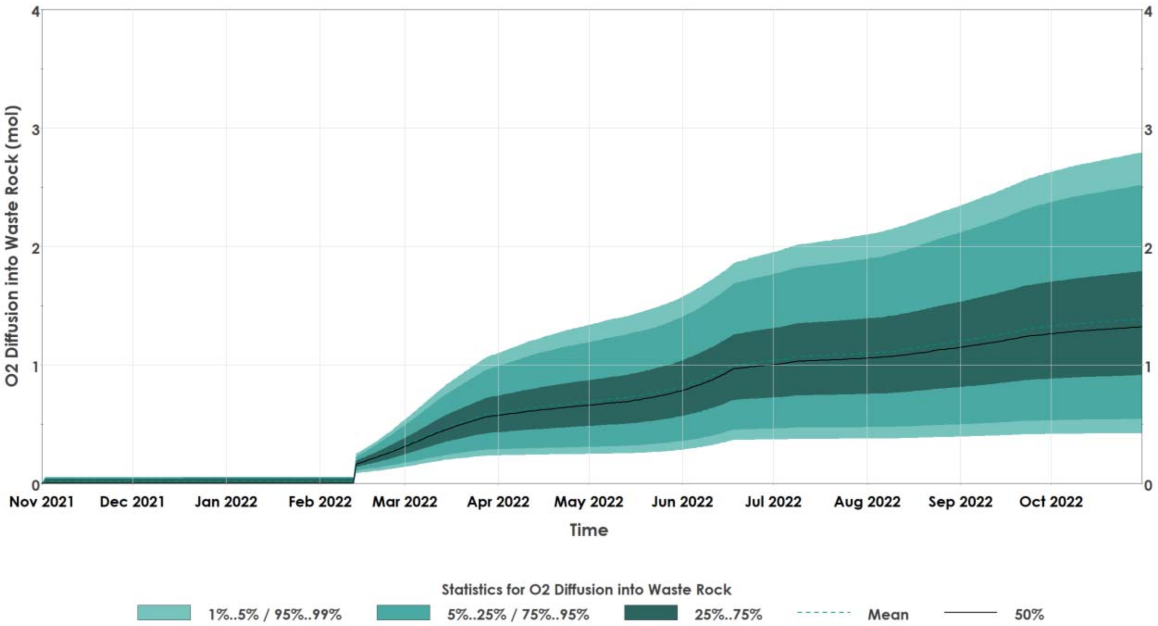


Figure 3.27: Oxygen diffusion simulation through cover materials on Trial #2 over a three-year monitoring period.

4 RECOMMENDATIONS

To further understand cover system performance, the following is recommended to be completed during the upcoming monitoring period:

- Continued performance monitoring as the cover trials are easily accessible, not infringing on mine operations, and require little maintenance and further investments. The learnings from the performance of the cover trials in response to varying climate conditions allow for better understanding of cover system performance at the Rainy River site.
- Generation of annual water balances to better understand climatic cycles and the influence of further established vegetation to modify the water fluxes.

4.1 Opportunities

Automated performance monitoring data has been collected at the field trials for approximately 4.5 years, which represents a substantial database of material properties and soil response to wet/dry and freeze/thaw cycling. The PAG cover trial database provides New Gold with a better understanding of cover system performance under varying climatic and vegetative conditions. The database will foster additional confidence in the results from the EMRS progressive reclamation cover construction, which started in late 2020.

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Appendix A

Photo Log

Photo A.1: East slope looking South; February 22, 2022 snow survey.

Photo A.2: Plateau of PAG Cover Trials looking West; February 22, 2022 snow survey.

Photo A.3: Trial #1 plateau showing established vegetation, looking East. September 22. 2022.

Photo A.4: Trial #2 plateau showing established vegetation, looking East. September 22, 2022.

Photo A.5: **Vegetation on Trial #2 South slope. September 22, 2022.**

Photo A.6: **Vegetation on Trial #1 South slope. September 22, 2022.**

Photo A.7: Trial #1 plateau established vegetation, looking East. September 22, 2022.

Appendix B

In Situ Instrumentation Measurements

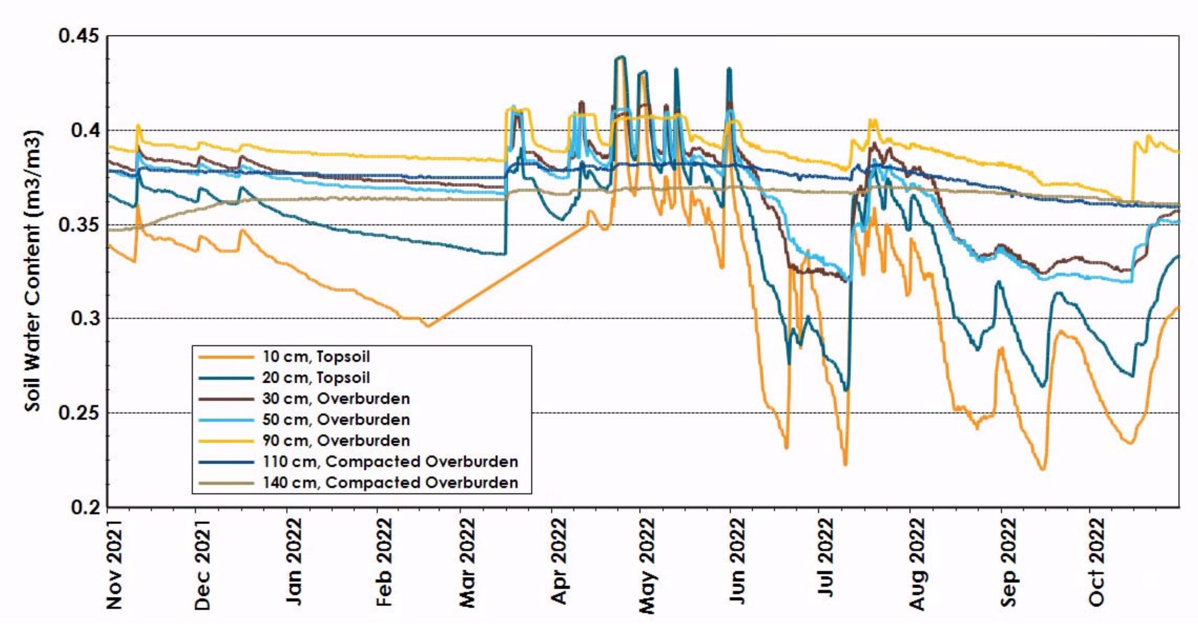

Figure B.1: VWC profile at Trial #1 primary station during the monitoring period.

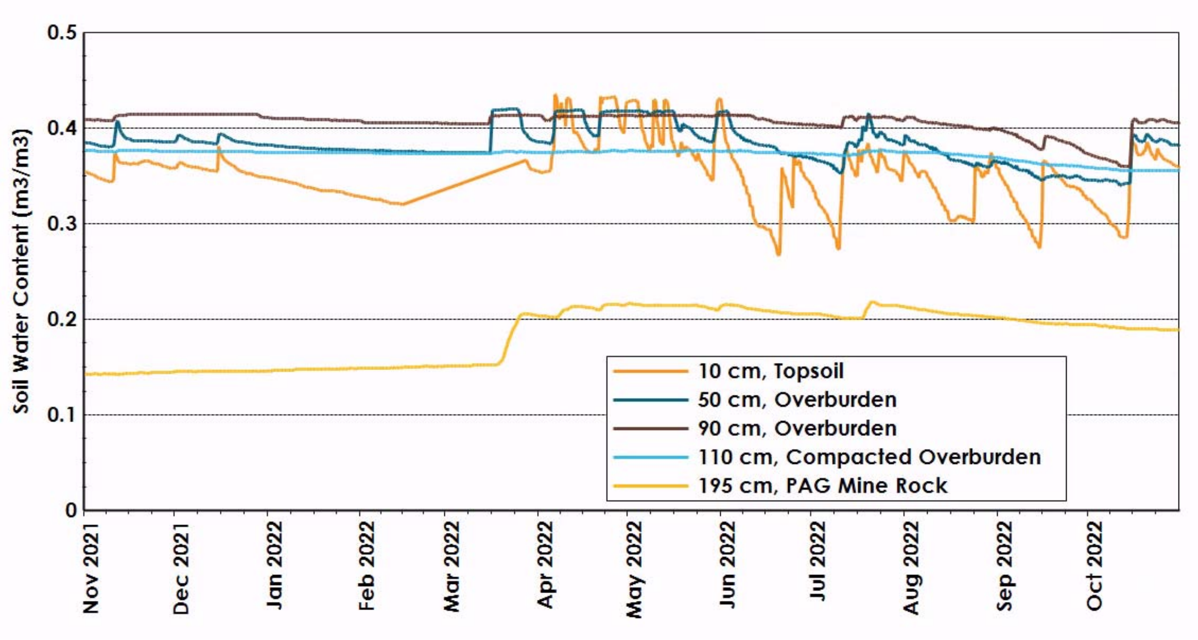

Figure B.2: VWC profile at Trial #1 secondary station during the monitoring period.

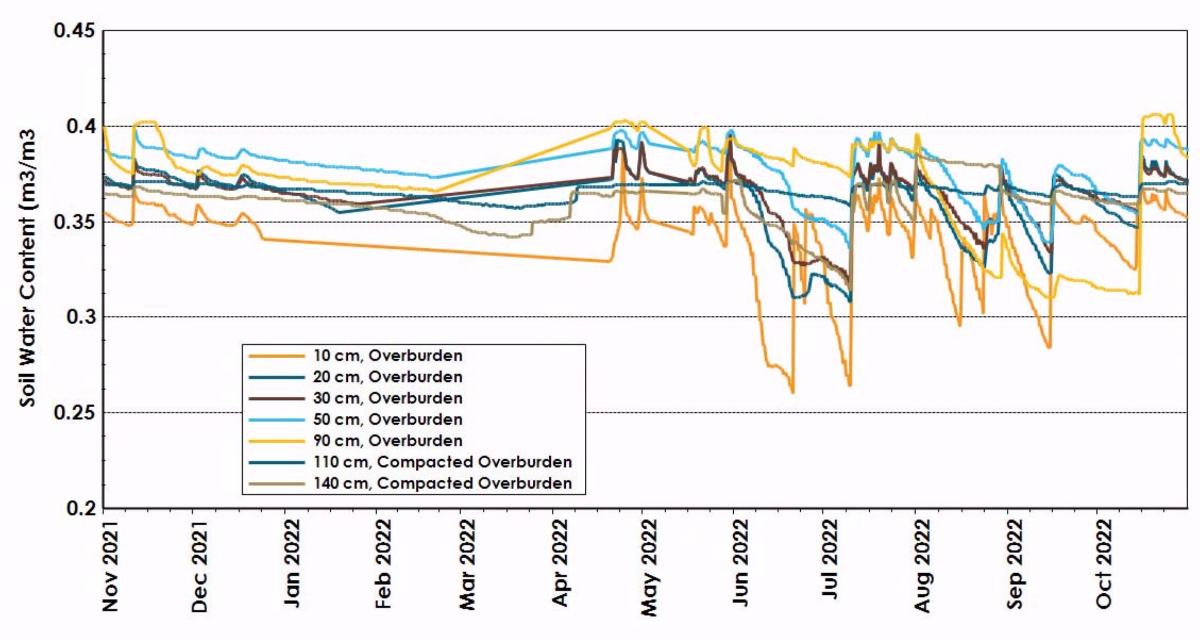

Figure B.3: VWC profile at Trial #2 primary station during the monitoring period.

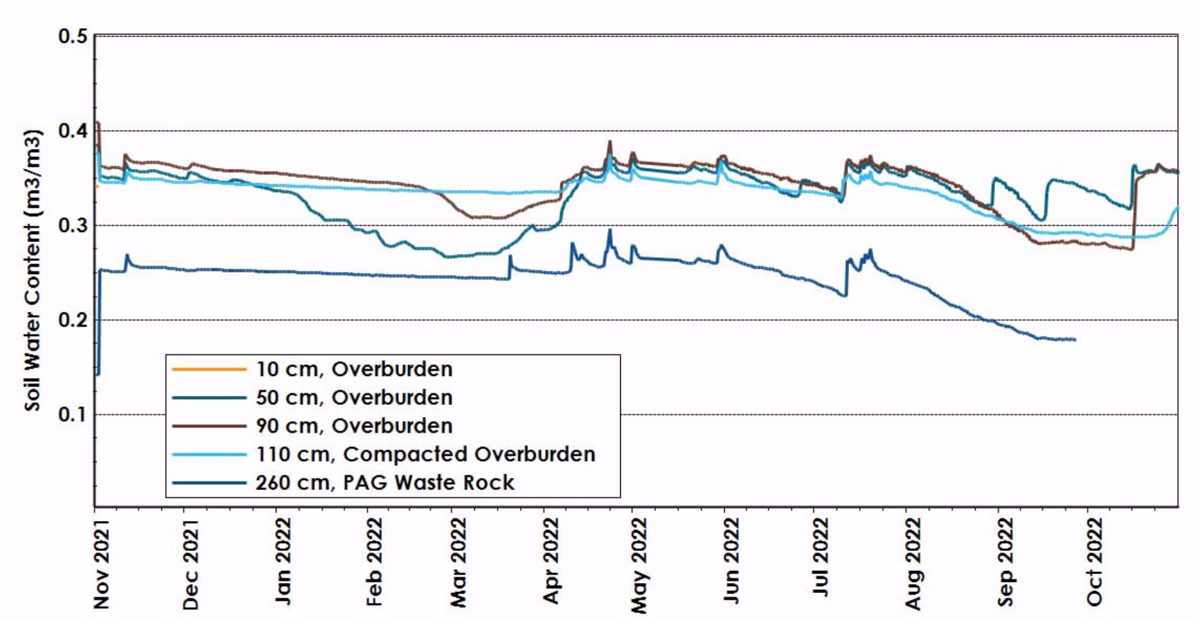

Figure B.4: VWC profile at Trial #2 secondary station during the monitoring period.

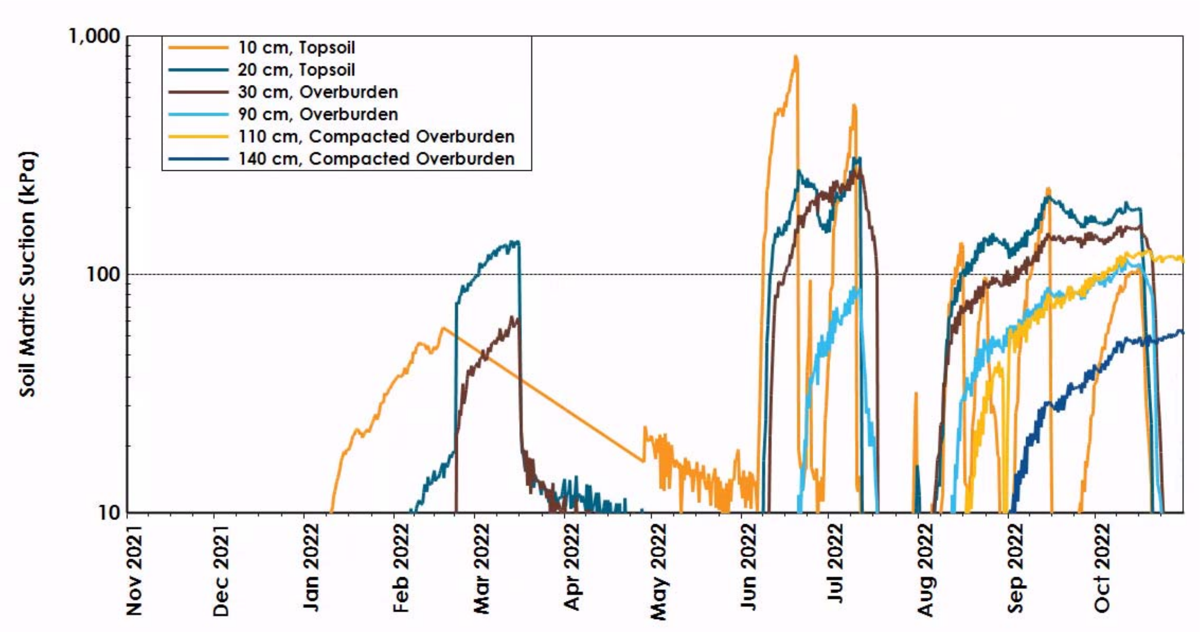

Figure B.5: Suction profile at Trial #1 primary station during the monitoring period.

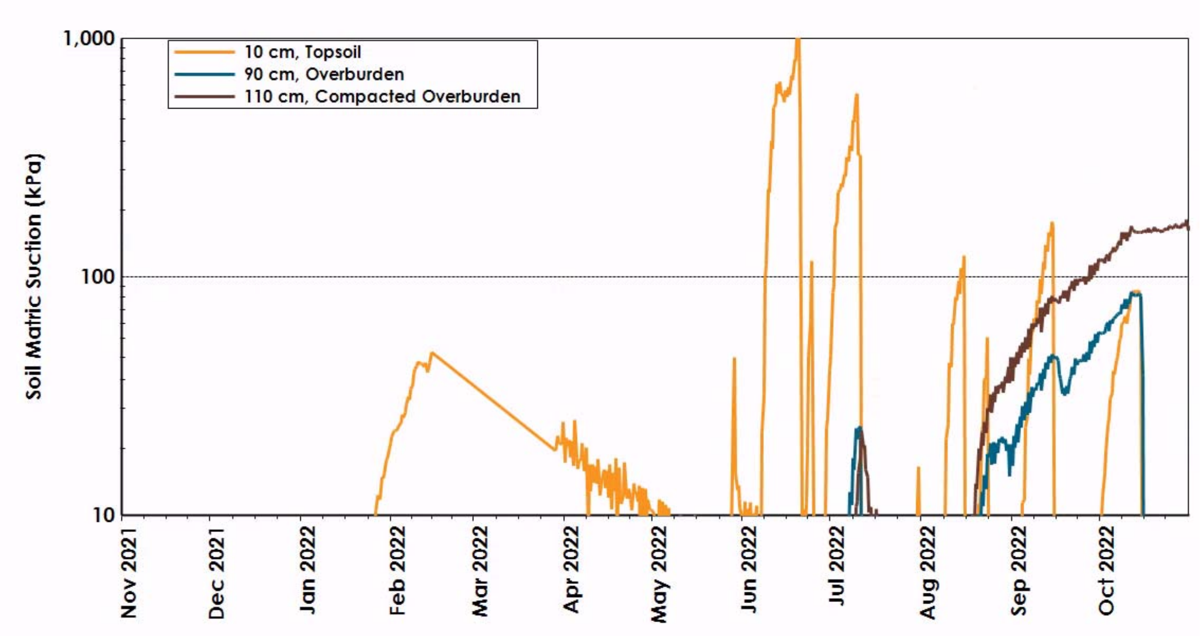

Figure B.6: Suction profile at Trial #1 secondary station during the monitoring period.

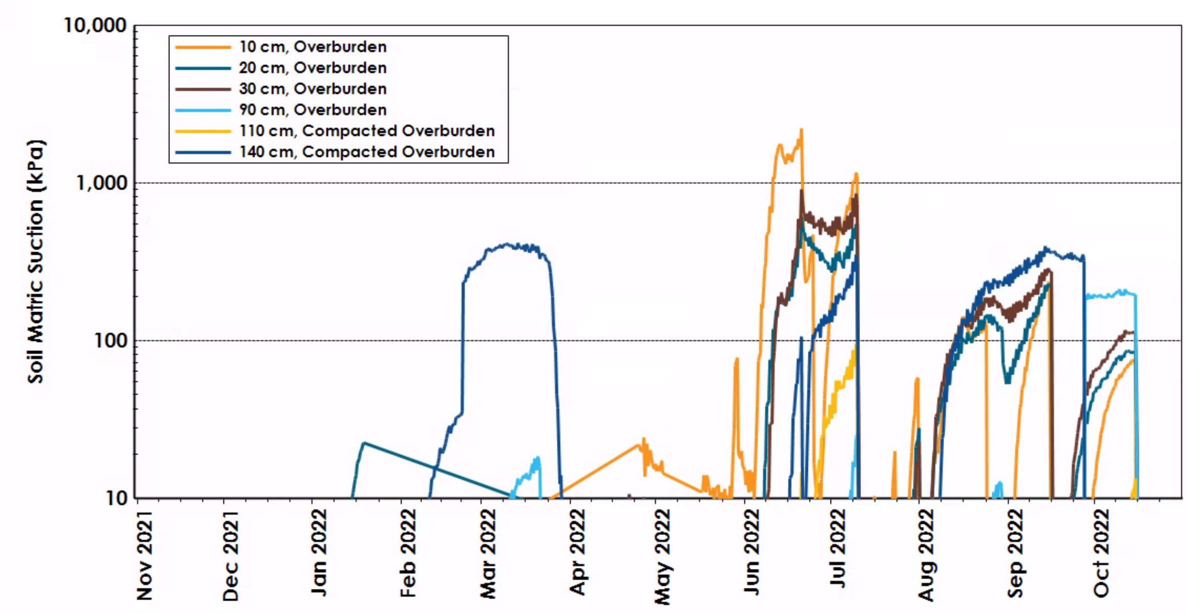

Figure B.7: Suction profile at Trial #2 Primary Station during the monitoring period.

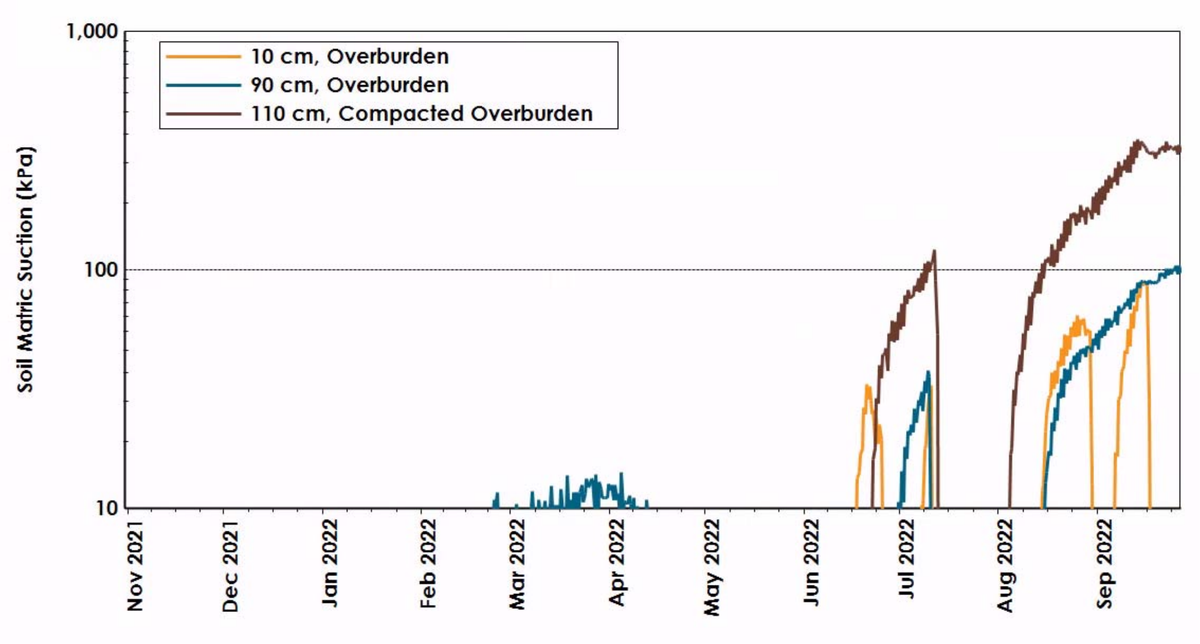

Figure B.8: Suction profile at Trial #2 Secondary Station during the monitoring period.

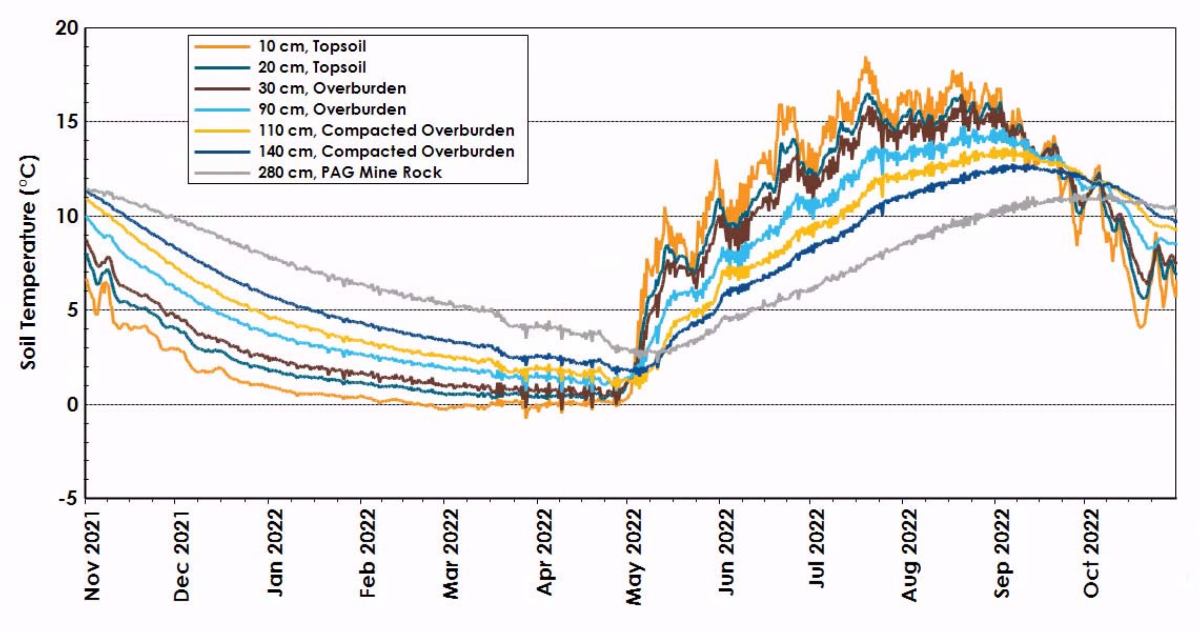

Figure B.9: Temperature profile at Trial #1 primary station during the monitoring period.

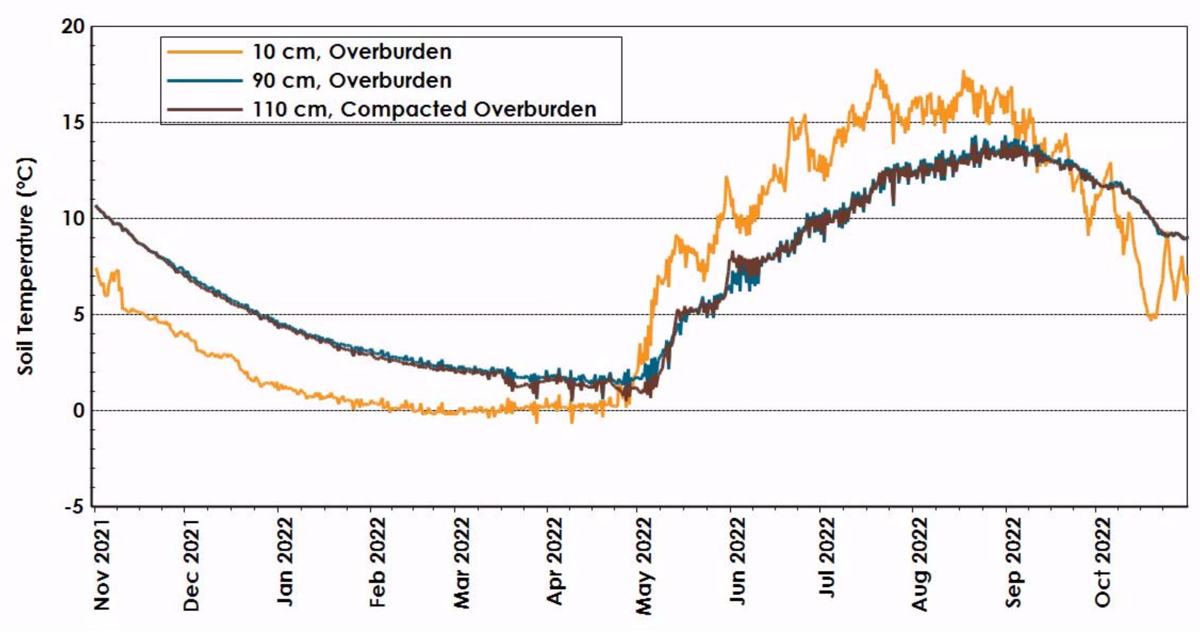

Figure B.10: Temperature profile at Trial #1 secondary station during the monitoring period.

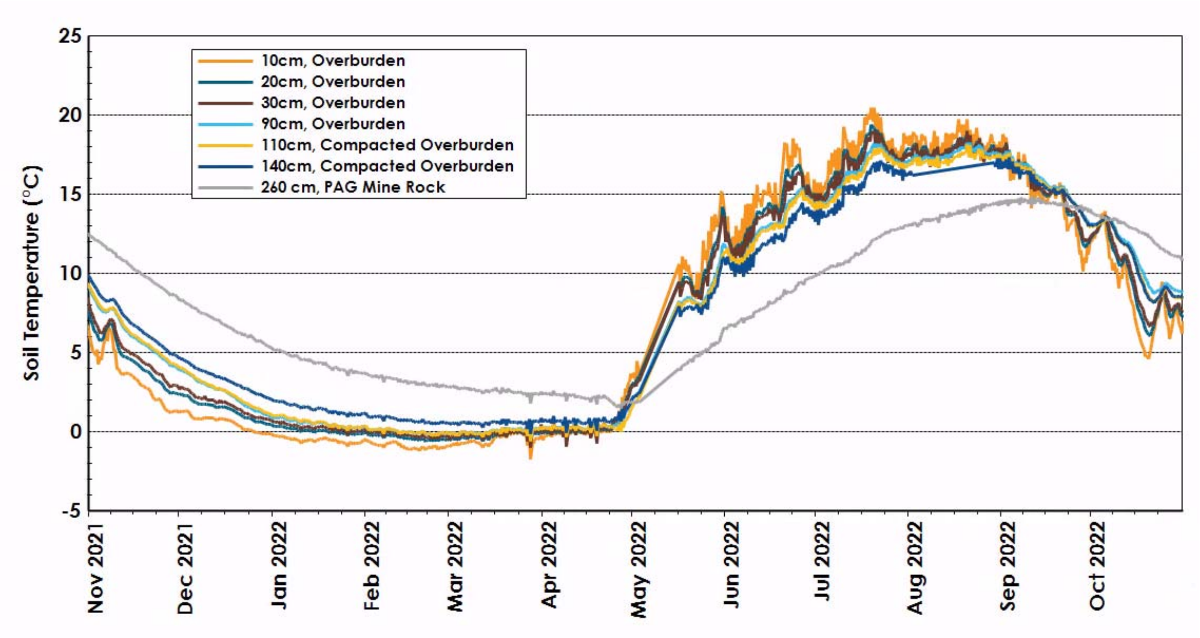

Figure B.11: Temperature profile at Trial #2 primary station during the monitoring period.

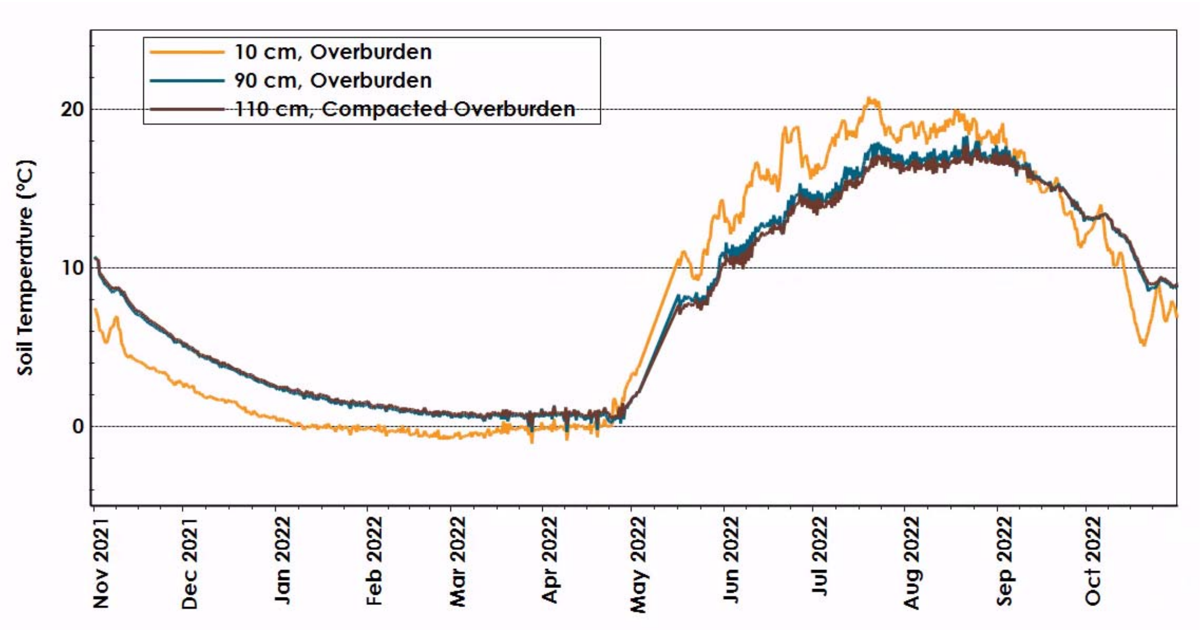

Figure B.12: Temperature profile at Trial #2 secondary station during the monitoring period.