Rainy River Mine - 2020 PAG Cover Trial 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. O'Kane Consultants Inc. (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 for the monitoring period of November 1, 2019 to October 31, 2020.

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 will provide 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 hand-seeding an appropriate seed-mix on Trial #2 in July 2019. The primary objectives of the cover system field trials are to evaluate the ability of overburden clay to manage oxygen ingress and net percolation through altering the water and gas balances.

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). Monitoring data recorded at the cover system field trials during the monitoring period show annual average saturation levels greater than 97% in the CBC. Maintenance of a 97% degree of saturation in the cover systems demonstrated that the compacted clay layer is retaining sufficient pore-water to prevent advection, and limit oxygen transport to diffusion through water.

Simple water balances were created for each cover system configuration to estimate net percolation of meteoric waters past the cover system into the underlying waste rock. The total estimated net percolation over the monitoring year was 9% and 16% for Trial #1 and Trial #2, respectively. The difference in net percolation rates was attributed to higher evapotranspiration rates on Trial #1 from thicker, established vegetation providing higher store and release capacity as well as creating a positive suction gradient within the compacted layer.

Performance monitoring of cover system 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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1 INTRODUCTION

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. O'Kane Consultants Inc. (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 monitoring data obtained between November 1, 2019 and October 31, 2020 (referred to herein as 'the 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 net percolation and oxygen ingress (closure); and

3) Update and refine conceptual models of performance for the cover system field trial area through examining changes in *in situ* gas concentrations after cover system placement and 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; and
- Section 4 – provides conclusions and recommendations based on key performance monitoring characteristics.

2 BACKGROUND

2.1 Description of Cover System Field Trials

Construction of the cover system field trials commenced October 2017 and was completed by 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 m2. 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 will provide 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. 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 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 will be 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 net percolation 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 that the cover 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.

Net percolation is limited by taking advantage of the store-and-release properties of the one-meter thick 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 net percolation 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 Rainy River Mine, the conceptual ranges of performance could be classified as very low net percolation (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 2019 – 2020 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 monthly automated data collection and data QA/QC, manual oxygen readings, field inspections, snow survey, and cover system performance updates (Table 2.1).

Table 2.1: Monitoring period activities

Activity	Date
Automated Data Download and QA/QC	January 14, March 3, May 5, June 30, July 23, November 12, 2020
Manual Oxygen Reading	January 14, March 3, May 5, June 30, 2020
Snow Survey	March 3, 2020
Site Visit & Instrumentation Maintenance	March 3, June 30, November 12, 2020
Performance Updates	May 22, July 23, 2020

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 collected at Rainy River Mine's Barron weather station.

3.1.1 Air Temperature

Annual average air temperature recorded at the Barron weather station during the monitoring period was 2.6 °C (Figure 3.3). Recorded daily air temperature at the Barron weather station was colder 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 evaluated frost penetration into the cover system. Between December and March 2020, ambient air temperature ranged from -40 °C to 8 °C and had an average temperature of -12 °C. Average daily temperatures during the winter of the current monitoring period were 5 °C warming compared to the 2018-2019 winter period.

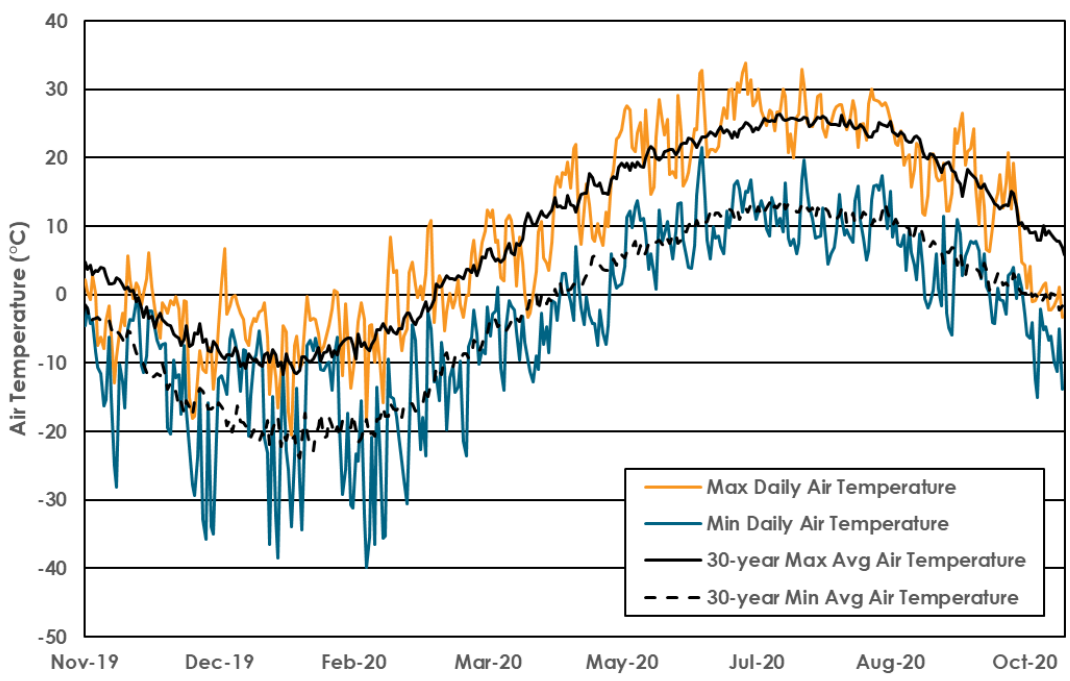

Figure 3.1: Maximum and minimum daily air temperatures recorded at Barron weather station as compared to 30-year averages.

3.1.2 Rainfall

Cumulative rainfall is measured with a tipping bucket gauge located on the plateau of Trial #2 (Figure 3.2). A total of 411 mm of rainfall was recorded during the monitoring period (141 mm less than the 30-year historic average). Monthly rainfall from April to October 2020 was compared to the 30-year historic average (Table 3.1). It was observed that April, May, July, and September were drier than average. Rainfall data measured on the cover system field trials were cross-referenced with that measured at the Barron weather station to ensure accurate data capture rates. Annual rainfall between the two stations was within ± 3% signifying no data was lost due to gauge error.

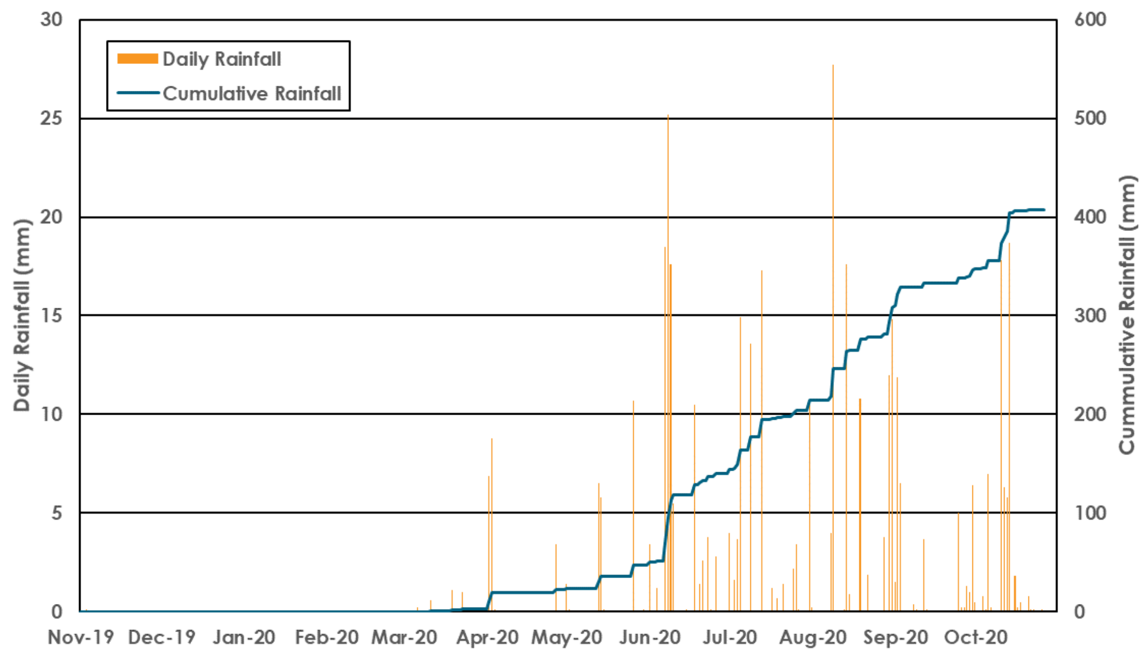

Figure 3.2: Daily and cumulative rainfall recorded at cover system field trials.

Table 3.1: April to October monthly rainfall

Month	2020		30-year Average	
	Rain Days	**Rainfall (mm)**	**Rain Days**	**Rainfall (mm)**
April	4	19.2	8	48.4
May	7	24.7	13	87.2
June	13	92.7	13	107.9
July	13	74.8	11	123.6
August	11	93.8	10	78.6
September	13	38.3	11	77.5
October	16	60.8	11	63.6

3.1.3 Snowfall

The tipping bucket rain gauge on the trial plateau only measures rainfall and does not directly measure now accumulation. A snow survey was conducted by Okane to measure the depth of the snowpack on each cover system field trial on March 3, 2020 (Figure 3.3) The measured snow density on Trial #1 and Trial #2 was 15% and 22%, respectively. The average measured snow-water equivalent (SWE) on the plateau of Trial #1 and Trial #2 was 60 mm and 66 mm, respectively.

In general, the snowpack was observed to have multiple visible layers signifying the surface has been wind blown and polished. Layers of faceted crystals were observed in some layers indicating periods of large temperature gradients.

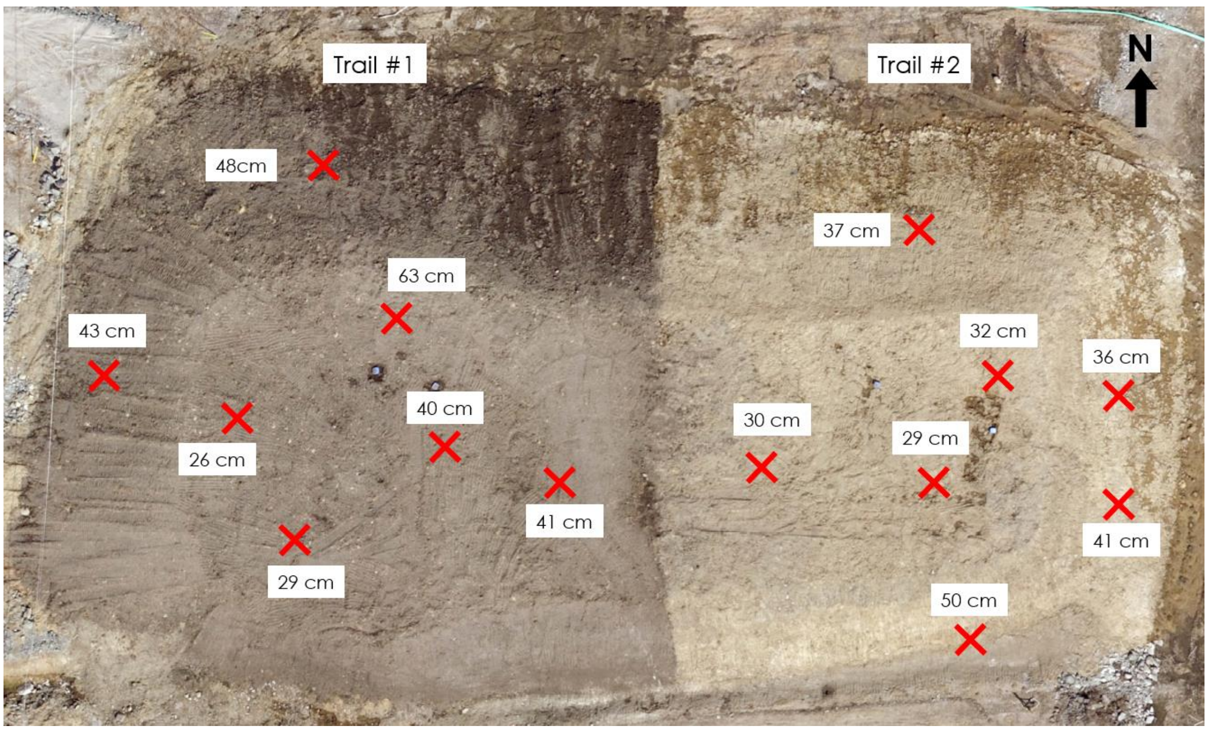

Figure 3.3: Snow survey locations and snowpack depths. March 3, 2020.

3.1.4 Reference Evapotranspiration

Key drivers of cover system performance in terms of net percolation are precipitation and energy available for 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 net radiation measured on the cover system surface.

Monthly ET_0 was compared to monthly rainfall for March to October (Figure 3.4). 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., April to September). During these months there is higher potential for drying of the compacted layer. Similarly, periods where ET_0 is less than rainfall observe an increase in water storage and increased potential for net percolation into the underlying mine rock material (e.g., October).

When compared to the 30-year average, higher drying rates were observed in June and July indicating more water was removed from the system than normal. An increase in storage would typically be observed in September, instead the drying trends continued into the fall indicating additional storage capacity within the system heading into the 2020 – 2021 monitoring year.

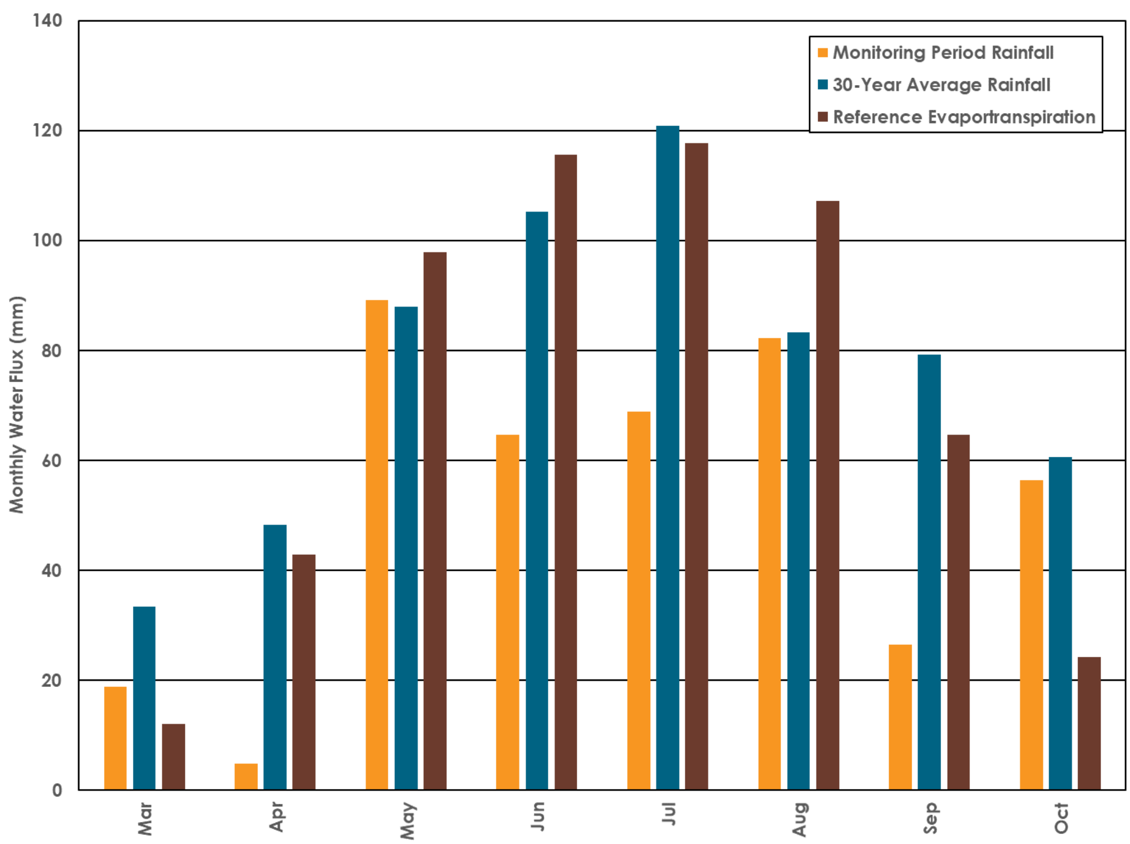

Figure 3.4: Reference Evapotranspiration and total rainfall measured at Rainy River Mine during March to October 2020.

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 December 9, 2019 and reach a maximum freezing depth of 30 cm (Figure 3.5). Freezing temperatures in Trial #2 was first observed December 17, 2019 and reached a maximum freezing depth of 10 cm (Figure 3.6). During the 2018-2019 winter, freezing temperatures in Trial #2 reached depths of 110 cm. The reduction in freezing depths observed during the current monitoring period can be attributed to vegetation growth on the Trial #2 plateau creating a thicker snowpack to provide an insulating layer between the cover system and ambient air temperatures.

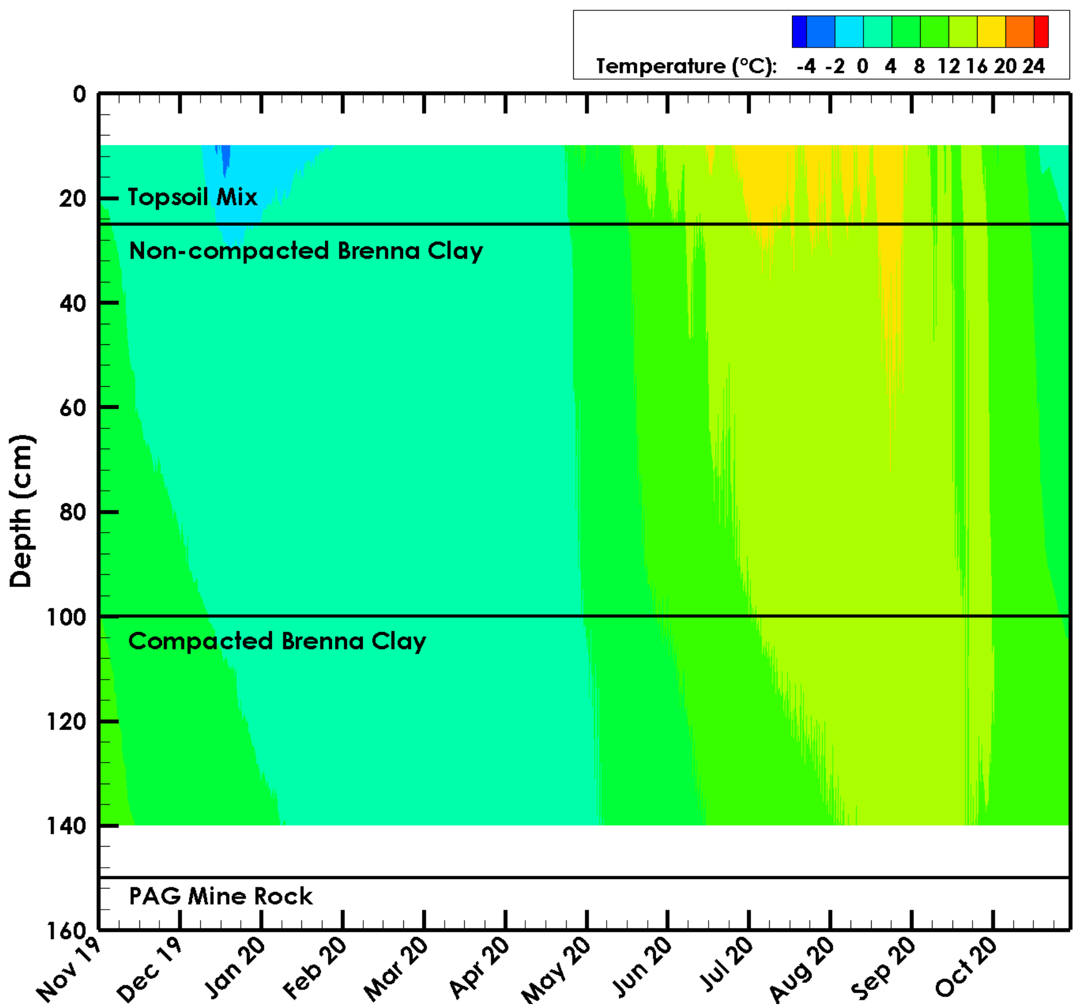

Figure 3.5: Soil temperature profile measured at Trial #1 Primary Nest during the monitoring period.

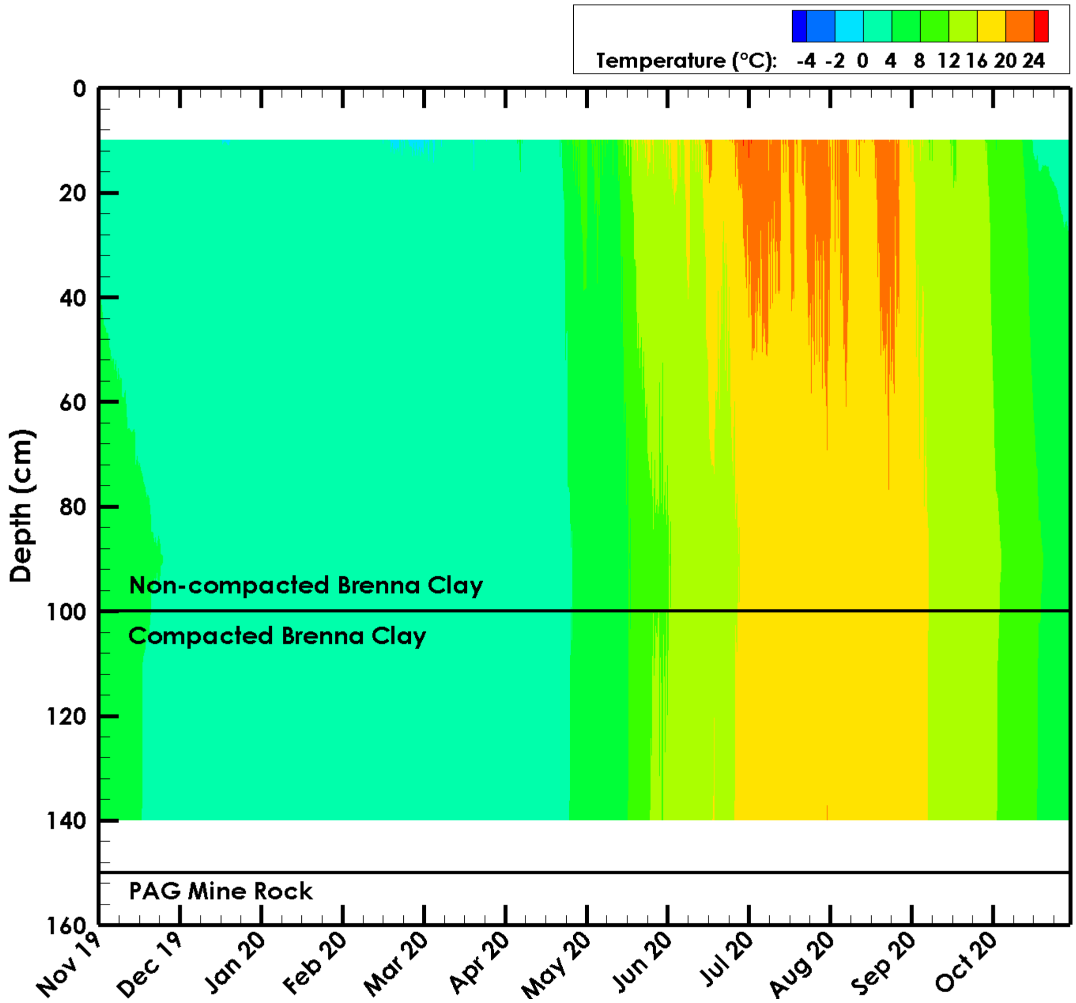

Figure 3.6: Soil temperature profile measured at Trial #2 Primary Nest during the monitoring period.

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. In order to successfully mitigate the ingress of oxygen into the underlying waste 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 show 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% (Table 3.2). 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 noncompacted overburden clay was also examined to assess the capability of the material to mitigate oxygen ingress during MRS construction. It was found that the top 50 cm of material had an average degree of saturation of 86%, while the bottom 50 cm of material has an average degree of saturation above 90% (Table 3.2). Although the noncompacted clay experienced periods below 85%, the noncompacted layer would be able to reduce oxygen ingress during construction for the majority of the year. It is clear from monitoring results that the objective of mitigating oxygen ingress is effectively achieved through the maintenance of a high degree of saturation in both the compacted and noncompacted layers.

The water cycling depth of each cover system was interpolated based on changes in volumetric water content at measured depths. The water cycling depth of Trials #1 (Figure 3.7) and Trial #2 (Figure 3.8) during the monitoring period was 60 cm and 30 cm, respectively. The deeper water cycling depth seen in Trial 1 is attributed to a greater evapotranspiration depth from the established vegetation.

Table 3.2: 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	87%	89%	100%	93%	97%
Trial #1 Secondary Nest	N/A	92%	100%	91%	97%
Trial #2 Primary Nest	85%	93%	100%	92%	97%
Trial #2 Secondary Nest	86%	87%	100%	94%	95%

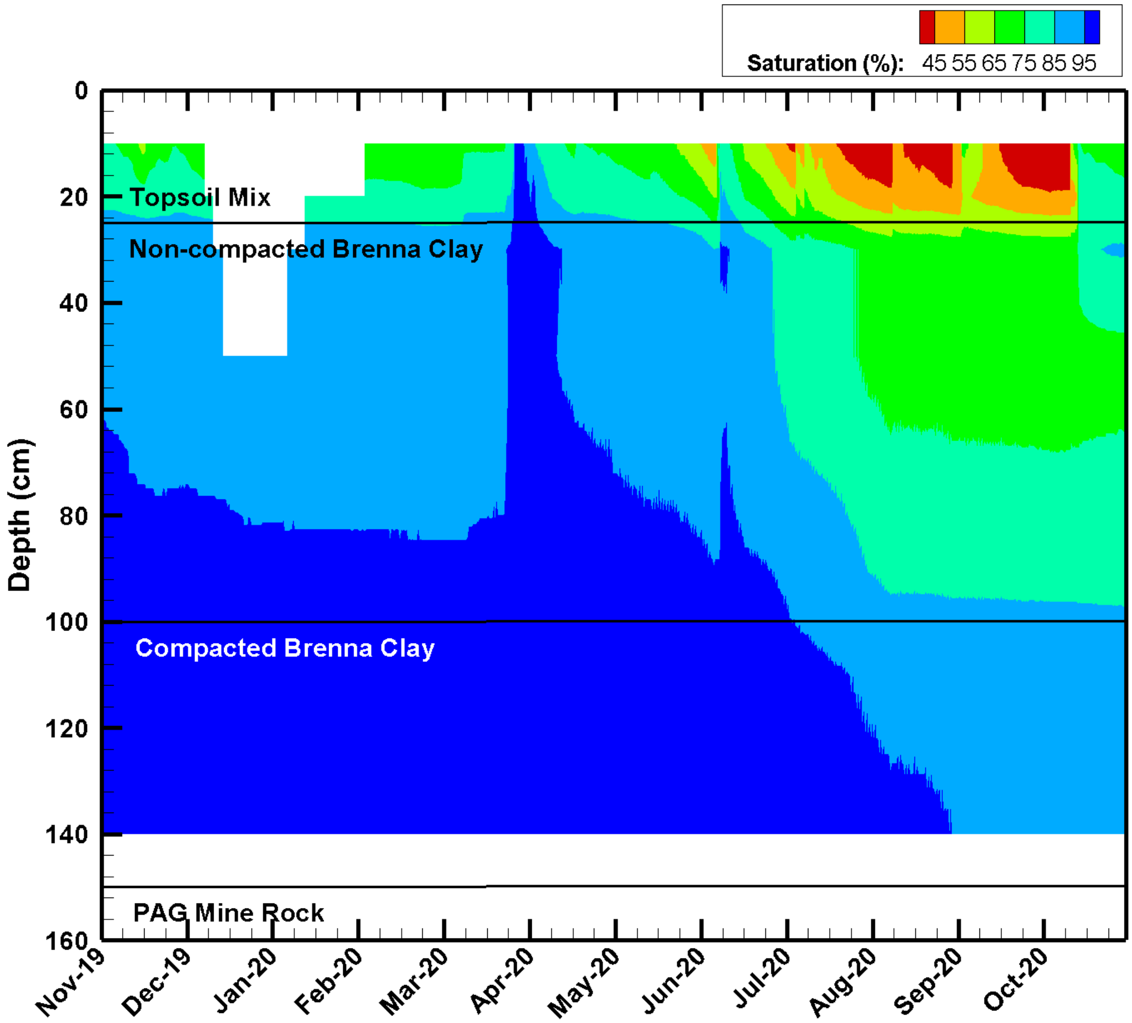

Figure 3.7: Change in degree of saturation at Trial #1 Primary Nest (white areas indicate periods of freezing temperatures).

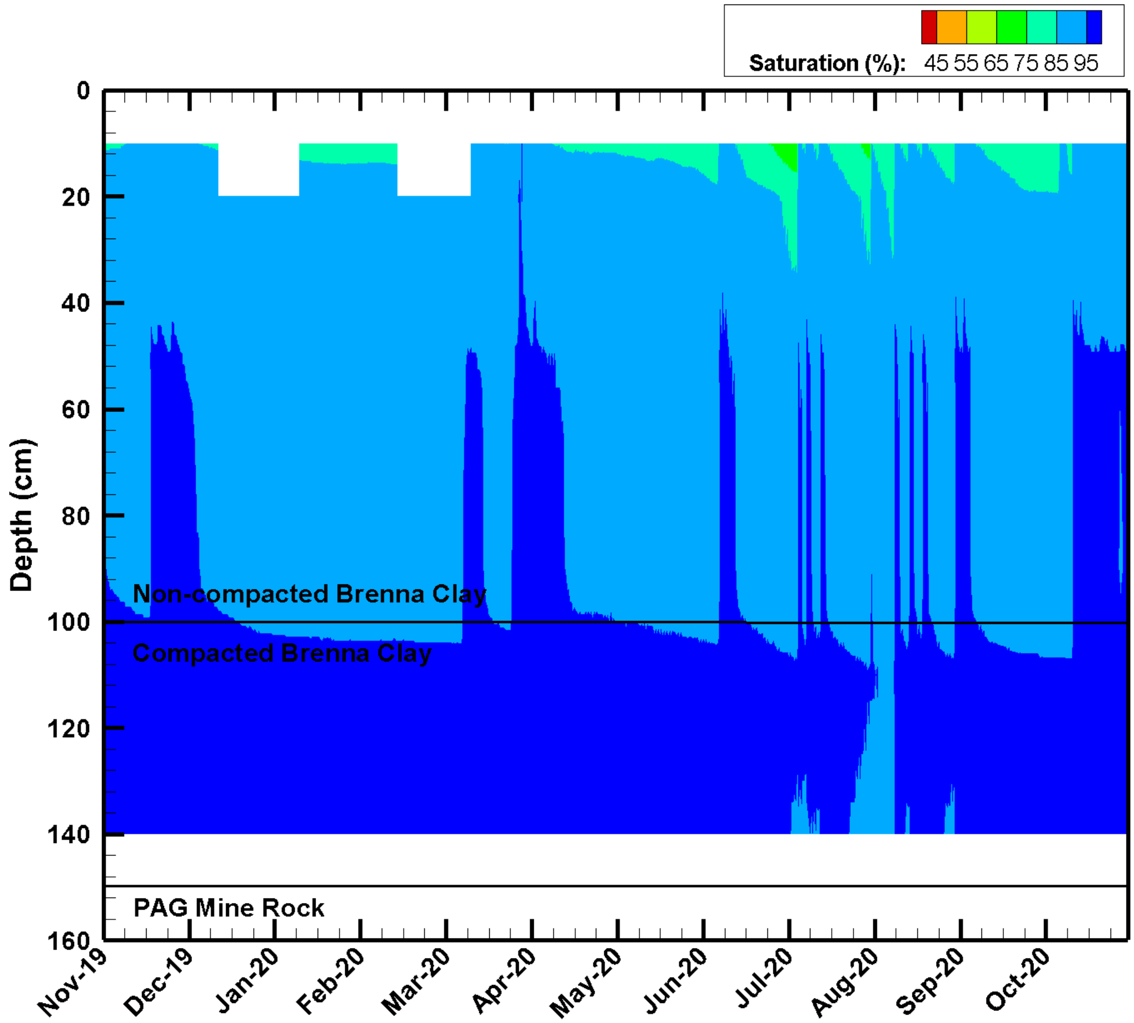

Figure 3.8: Change in degree of saturation at Trial #2 Primary Nest (white areas indicate periods of freezing temperatures).

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 and are not considered to be accurate. Overall, Trial #1 (Figure 3.9) observed higher suction values deeper within the cover system than Trial #2 (Figure 3.10) (suction values > 500 kPa within the compacted layer). The higher suction values in Trial #1 were primarily attributed to the established vegetation's ability to translocate water out of the soil matrix. Although elevated suction values were recorded within the compacted layer, a high degree of saturation was still maintained showing that the compacted clay has a high permanent wilting point (PWP) and that even under high suction values water is unable to be pulled from the soil matrix.

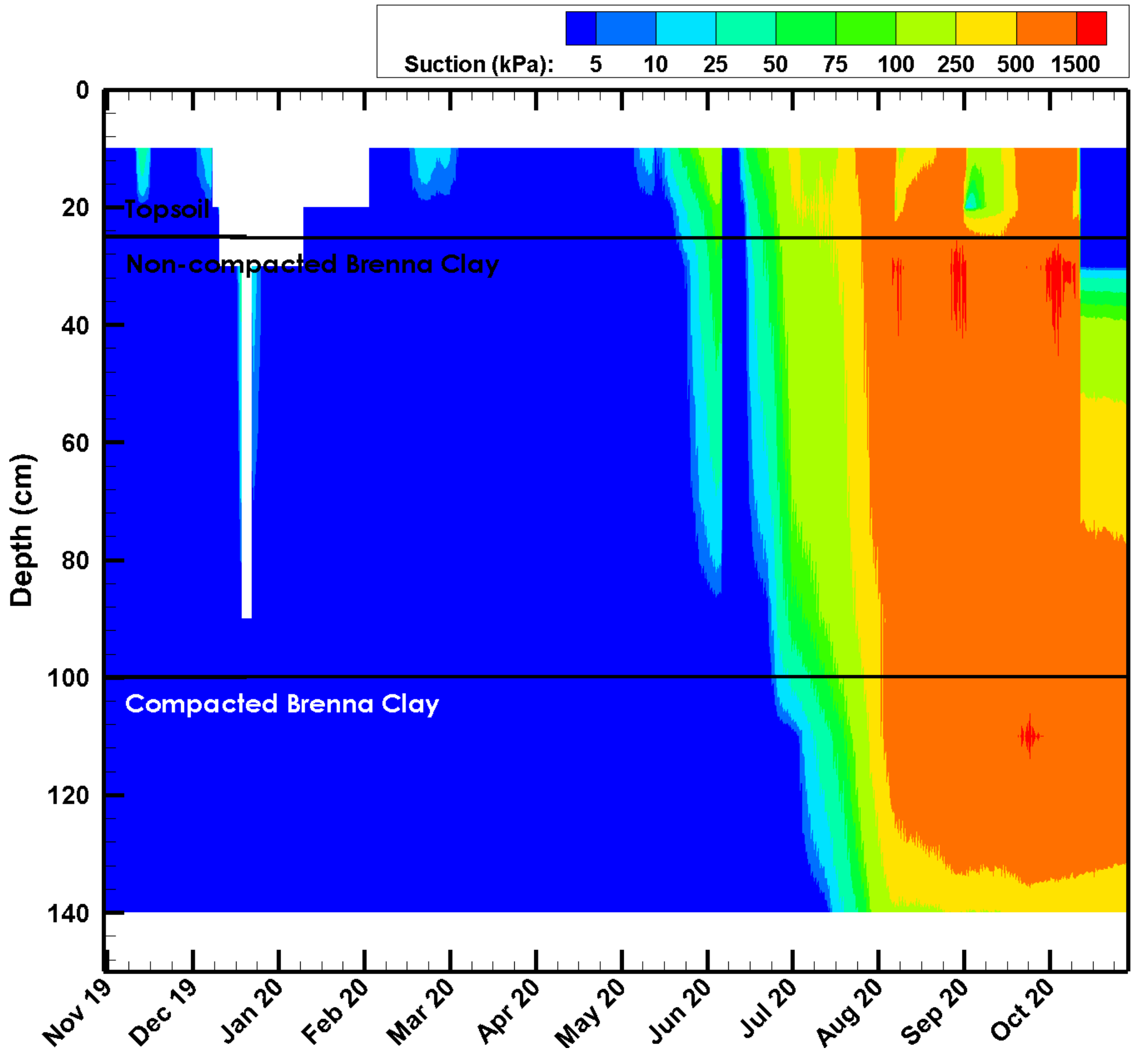

Figure 3.9: Matric suction profile measured at Trial #1 Primary Nest (white areas indicate periods of freezing temperatures).

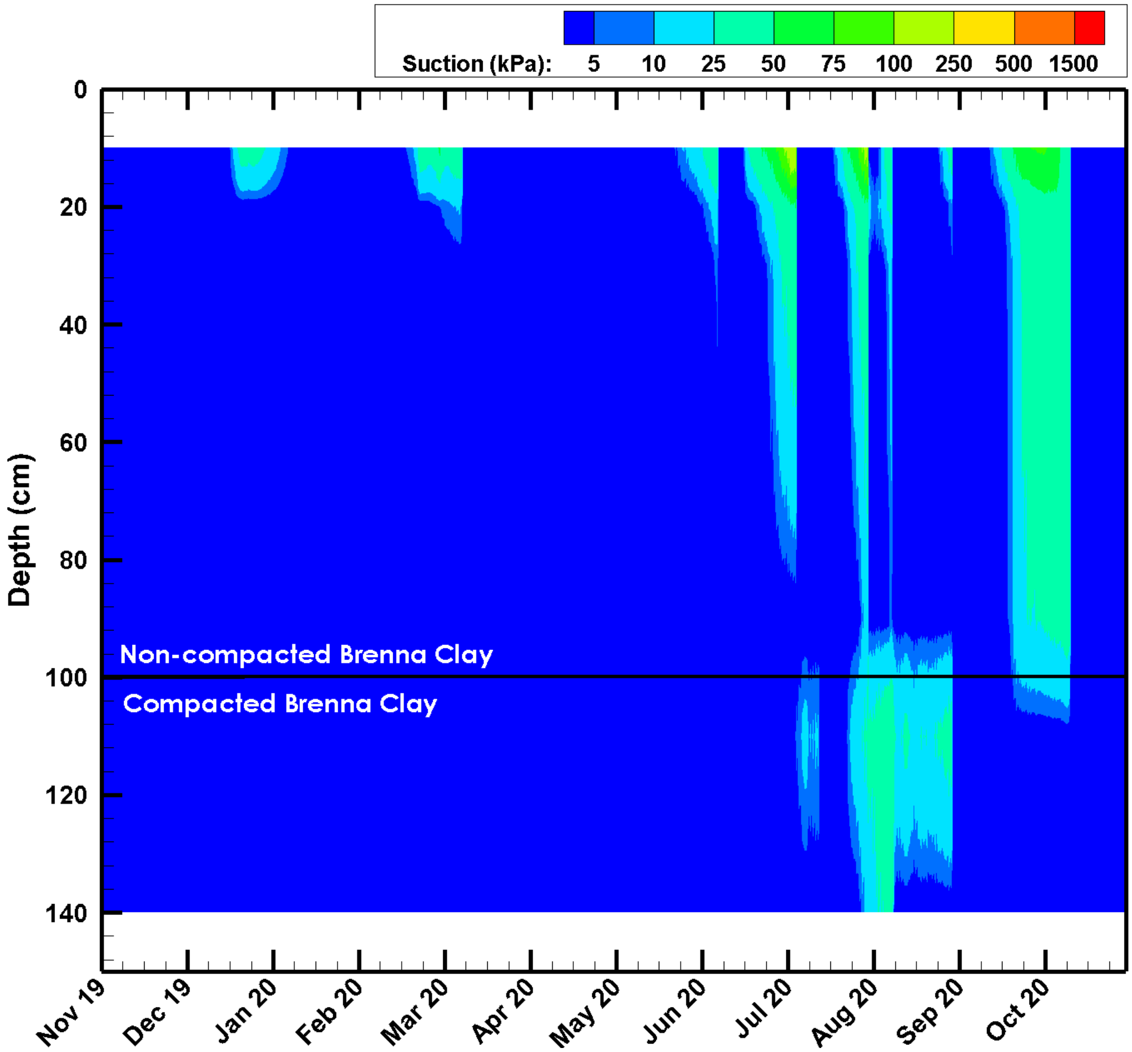

Figure 3.10: Matric suction profile measured at Trial #2 Primary Nest.

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 example, if sensors are placed at 10 cm, 20 cm, and 30 cm the representative layers would be 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 net percolation 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 #1 observed a greater decrease in stored water than Trial #2 from June to August (Figure 3.11). The decrease in storage allows for new precipitation to be stored within the soil profile and not infiltrate to the underlying mine rock. If vegetation is not able to be established on the clay overburden the cover system will not be as effective as a store-and-release system.

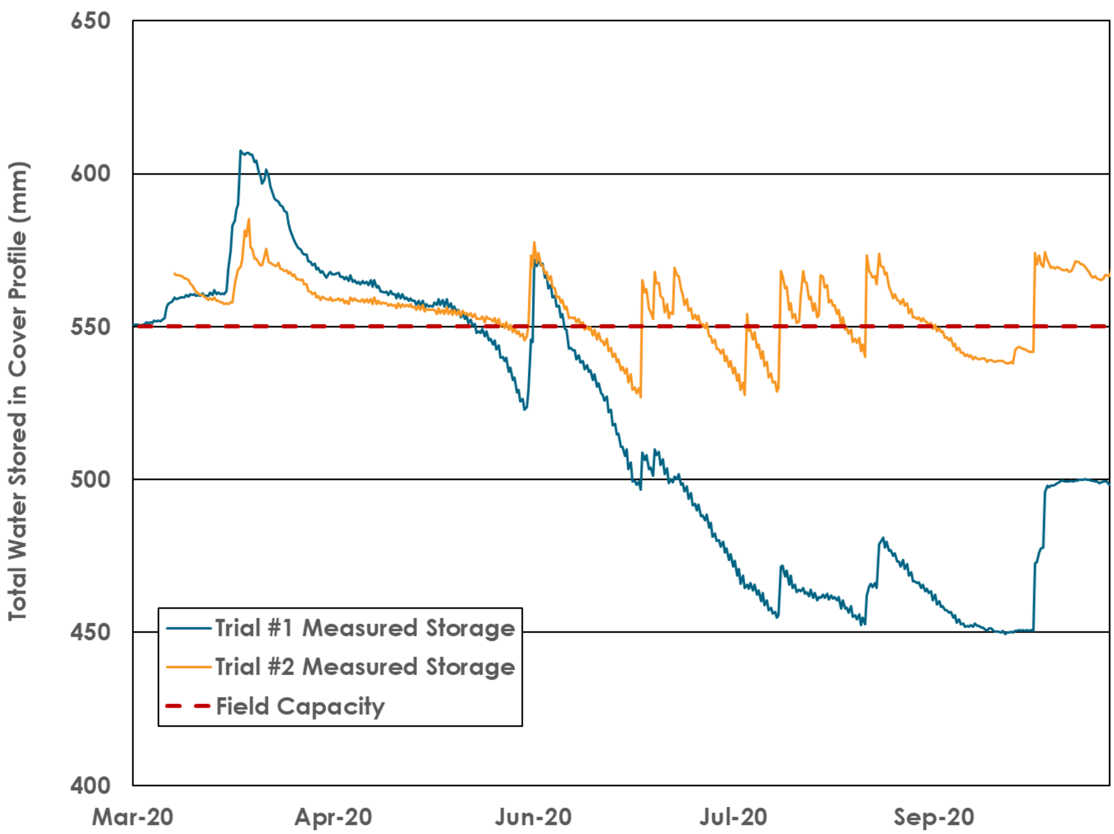

Figure 3.11: Measured storage vs. cover system field capacity.

3.4 Water Balance

3.4.1 Discussion of Water Balance Inputs

Simple water balances were created for each primary station to estimate the volume of water percolating through the cover system to the underlying waste rock. The water balances were based on *in situ* measurements, site-specific climate data, and solving the water balance equation daily (Equation 1). The estimation and application of each of these components in calculating the water balance is discussed briefly below.

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

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 at tipping bucket rain gauge to measure rainfall and measured SWE of 0.15 and 0.22 kg/m^2. Daily spring melt was estimated by 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 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.

The primary purpose of the water balance is to estimate net percolation rates. Net percolation 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 net percolation. Therefore, the uncertainty associated with the individual components of the water balance are compounded when estimating net percolation. Water balance uncertainties are constrained to the extent possible using engineering judgement. The estimated net percolation 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.

3.4.2 Water Balance Results

Calculated change in storage matched measured change in storage reasonably well for Trial #1 (Figure 3.12) and Trial #2 (Figure 3.13) water balances. Net percolation in Trial #1 followed performance outlined in the conceptual model and produced low net percolation rates according to the INAP Guidance Document for the given climate region (INAP 2017). Net percolation in Trial #2 was 16% of the annual precipitation (Table 3.3) resulting moderate net percolation rates. The primary component resulting in the difference in net percolation rates is the difference in evapotranspiration rates between the two configurations. The thicker, established vegetation observed in Trial #1 applied higher evapotranspiration rates. The higher evapotranspiration rates limited net percolation through:

1) Creating a positive pressure gradient within the compacted clay layer during the summer months, effectively shutting down net percolation during periods with suction values greater than 20 kPa. When suction rates are below 20 kPa infiltrated waters can freely drain from the compacted layer resulting in higher net percolation rates (Figure 3.14).

2) Increasing the effectiveness of the store and release component of the cover system allowing for more incoming precipitation to be stored within the cover system profile.

Table 3.3: Water balance components

	ET_0 mm (% PPT)	**Runoff mm (% PPT)**	**Net Percolation mm (% PPT)**
Conceptual Model	50 – 70%	10 – 20%	5 – 15%
Trial #1	378 (80%)	114 (24%)	43 (9%)
Trial #2	287 (60%)	113 (23%)	75 (16%)

PPT = Annual Precipitation

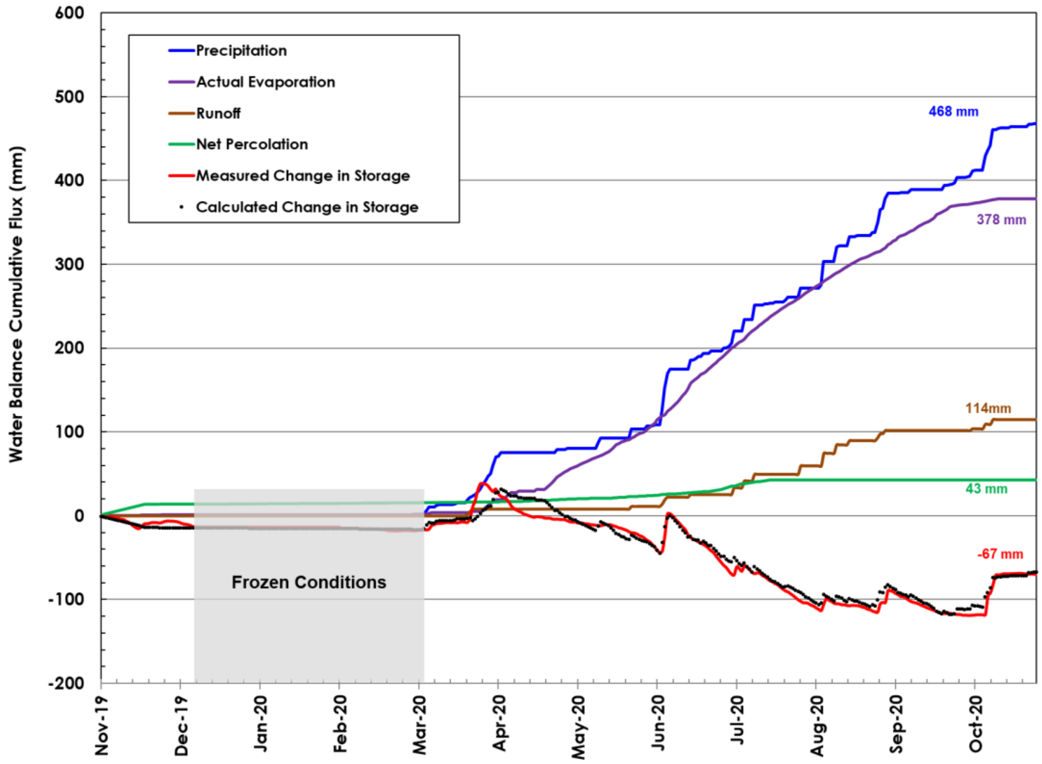

Figure 3.12: Cumulative water balance fluxes for Trial #1 for the monitoring period.

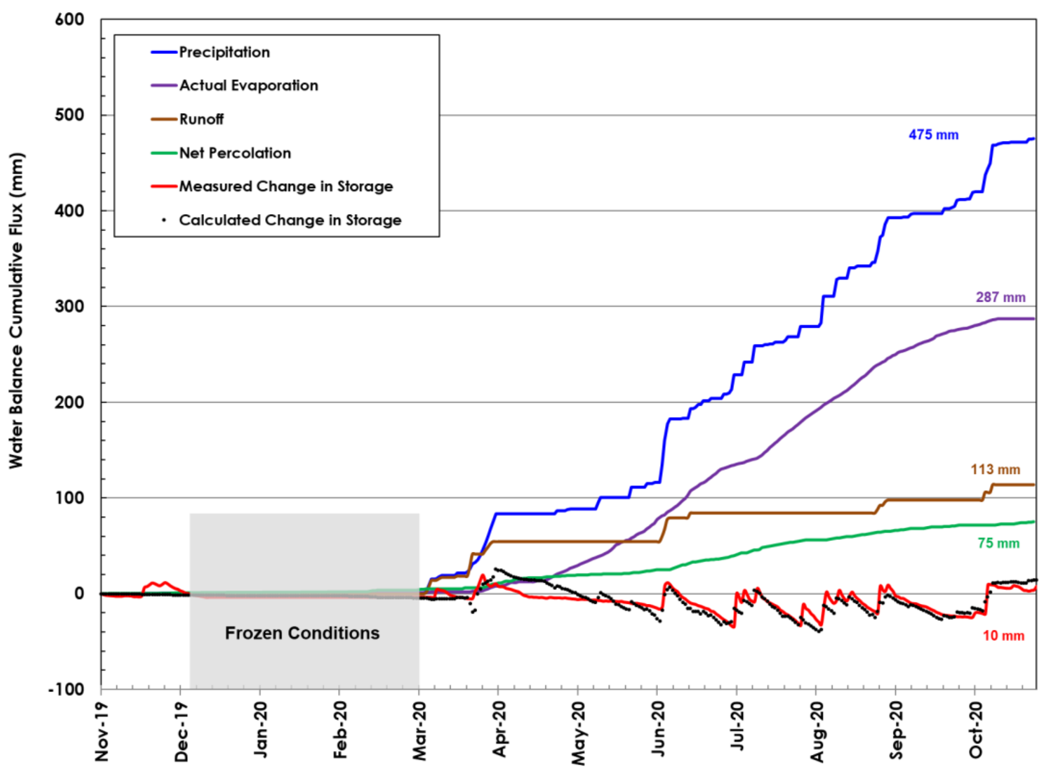

Figure 3.13: Cumulative water balance fluxes for Trial #2 for the monitoring period.

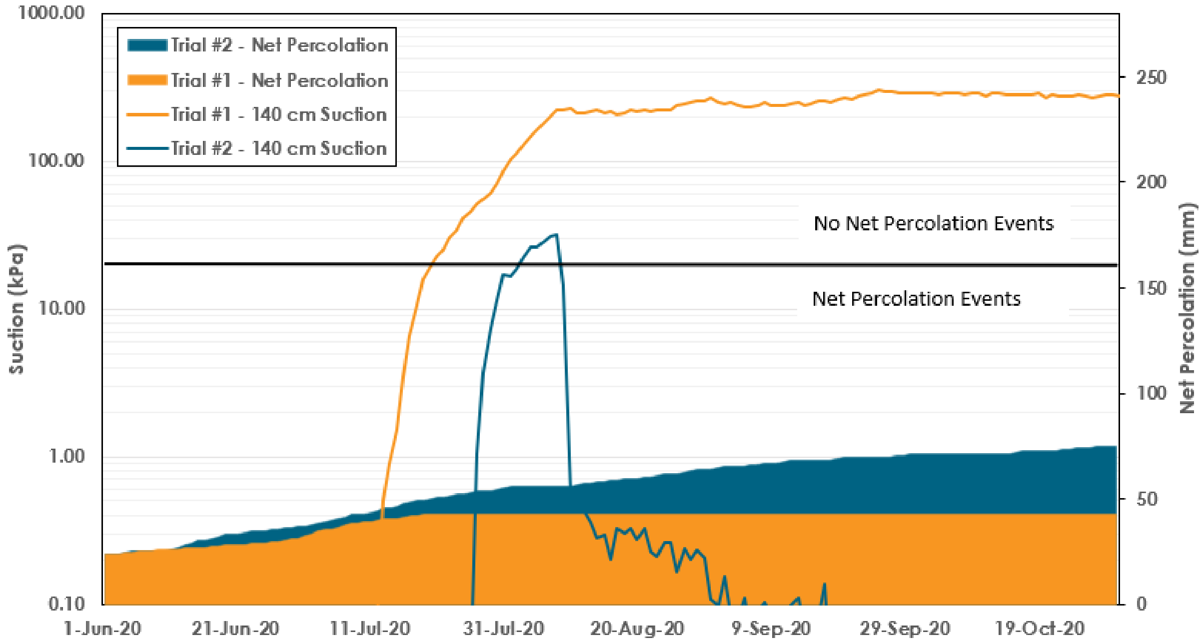

Figure 3.14: Suction observed in compacted layer base vs. net percolation.

3.5 Oxygen Ingress

Automated oxygen sensors located in the underlying waste rock were monitored to observe the ingress and consumption of oxygen. Fluctuations in oxygen concentrations were observed during the monitoring period (Figure 3.15). Oxygen concentrations within all instrumentation nests show similar trends to that presented below.

As saturation levels of the cover system compacted layers have remained sufficiently saturated to limit oxygen advective and diffusion, the observed increase in oxygen concentrations has been attributed to insufficient thickness of the clay key surrounding the field trials allowing oxygen to bypass the cover system. 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. Therefore, oxygen ingress evaluation through the cover system will focus on the degree of saturation maintained within the compacted layer.

The learnings from the trial construction have been leveraged in the design of the EMRS progressive reclamation cover system and specifically in the clay key in requirements at the toe of the cover system.

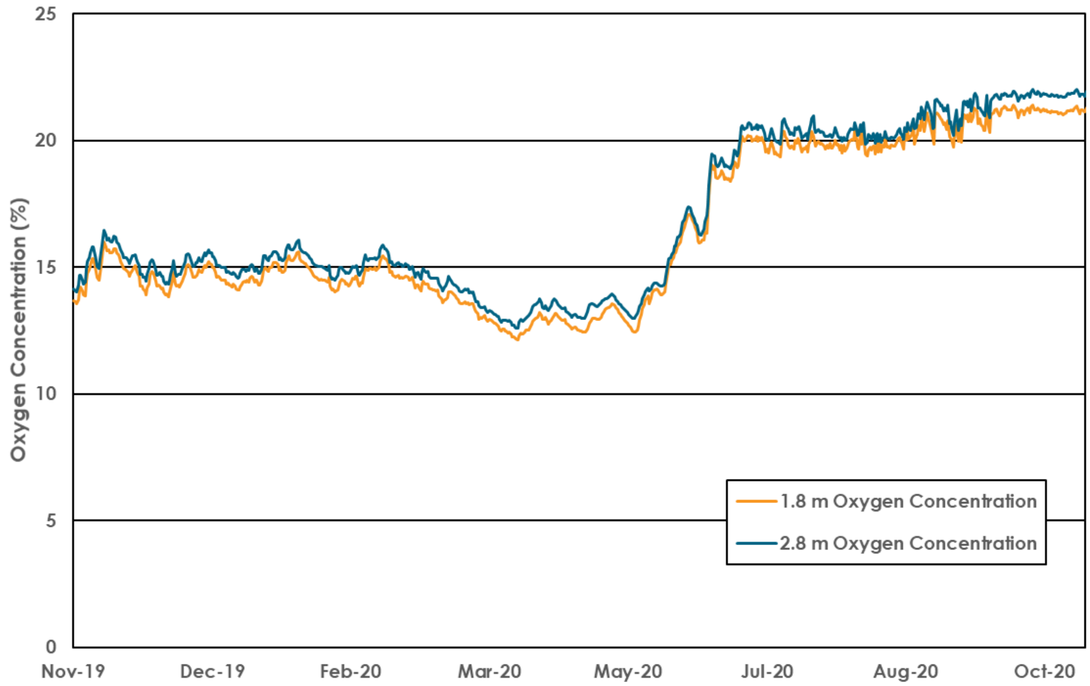

Figure 3.15: Oxygen concentration in waste rock below Trial #1 Primary Nest.

4 EVOLUTION OF COVER SYSTEM PERFORMANCE

The 2019-2020 monitoring period presents the second monitored water year studied at the PAG cover system field trials. The continuous monitoring conducted at the field trials allows to better understand climatic cycles and the influence of further established vegetation to modify the water fluxes. Details of the 2018-2019 monitoring period can be found in the 2019 Annual Monitoring Report (Okane, 2020).

4.1 Precipitation Influences

Rainfall during 2018-2019 and 2019-2020 monitoring periods was 593 mm and 411 mm, respectively. The water content within the compacted layer maintained an average degree of saturation above 97% and 95% for Trial #1 and Trial #2, respectively and has limited the ingress of oxygen throughout both monitoring years.

4.2 Vegetation Effects

Vegetation has been observed to play an important and dominant role in cover system performance. Frost penetration depth in Trial #2 varied between the two monitoring periods, despite freezing temperatures remaining constant within Trial #1. During the 2018-2019 monitoring year, the surface of Trial #2 remained bare and freezing temperatures reached a depth of 110 cm. Conversely, freezing temperatures only reached 10 cm once vegetation was established. The difference in vegetation allowed for a thicker snowpack to develop over the cover system providing insulation from extreme ambient air temperatures.

Vegetation has also influenced evapotranspiration rates over both monitoring years. Evapotranspiration rates within both Trail #1 and Trial #2 have increased annually as more vegetation establishes on the surface. Higher evapotranspiration rates allow for a more effective store and release system thereby reducing annual net percolation rates (Table 4.1).

Table 4.1: Water Balance Evolution

	Trial #1		Trial #2	
	2018-2019 Monitoring Period	**2019-2020 Monitoring Period**	**2018-2019 Monitoring Period**	**2019-2020 Monitoring Period**
ET_0 (% PPT)	64%	80%	50%	60%
Runoff (% PPT)	26%	24%	41%	23%
Net Percolation (% PPT)	10%	9%	12%	16%

5 RECOMMENDATIONS

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

- Due to the observed oxygen ingress pathways, monitoring oxygen concentrations is not a definitive approach to measure the ability of the cover system to mitigate oxygen ingress. Therefore, Okane recommends that oxygen ingress through the cover system be evaluated on the degree of saturation maintained within the compacted layer.
- Generation of annual water balances to better understand climatic cycles and the influence of further established vegetation to modify the water fluxes. A continuous 3-year water balance can be completed following the upcoming monitoring year to better show store and release processes of the non-compacted layers.

5.1 Opportunities

Automated performance monitoring data has been collected at the field trials for approximately 2.5 years, which represents a substantial database of material properties and soil response to wet/dry and freeze/that cycling. The PAG cover trial database provides New Gold a head start if there is a requirement to update predicted long-term cover system performance or a need to optimize cover system configuration in response to material availability constraints. The database offers field-derived material properties and the opportunity to calibrate predictive models to observe conditions, which both facilitate the performance prediction program and fosters additional confidence in the results. Upcoming work to optimize the West Mine Rock Stockpile cover system will utilize these opportunities.

6 REFERENCES

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Appendix A

Photo Log

Photo A.1: Snow pack showing snowy facets and layering indicating periods of melting.

Photo A.2: Trial #1 overview showing established vegetation, looking West. May 5, 2020.

Photo A.3: Trial #2 overview showing established vegetation, looking East. May 5, 2020.

Photo A.2: Trial #2 overview showing established vegetation, looking East. June 30, 2020.

Photo A.4: Trial #1 overview showing established vegetation, looking west. June 30, 2020.

Photo A.5: Trial #2 slope overview showing established vegetation, looking East. June 30, 2020.

Photo A.5: Trial #1 slope overview showing established vegetation, looking West. June 30, 2020.

Photo A.5: Comparison of vegetation on Trial #1 and Trial #2 slope, looking West. June 30, 2020.

Appendix B

In Situ Instrumentation Measurements

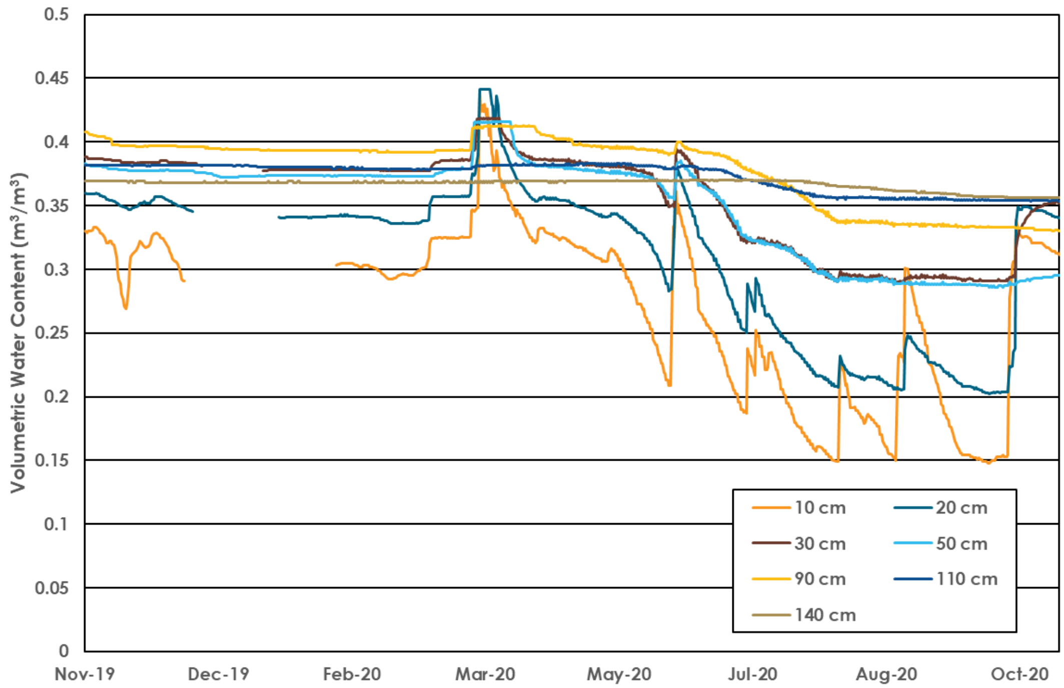

Figure B.1: VWC profile at Trial #1 Primary Station during the monitoring period.

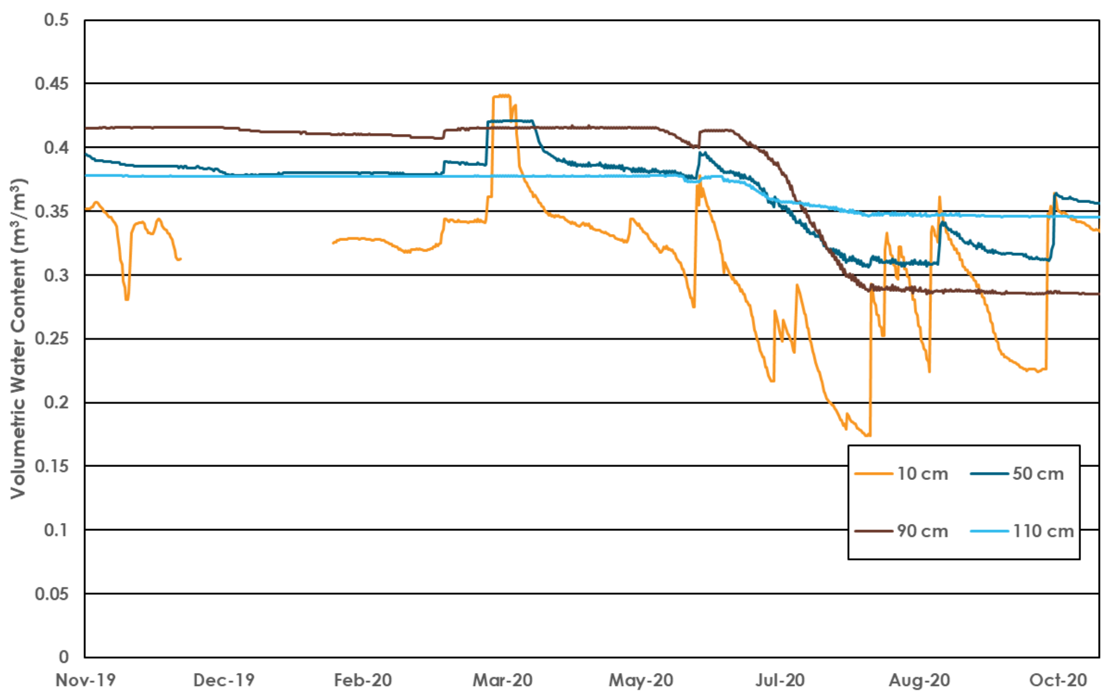

Figure B.2: VWC profile at Trial #1 Secondar Station during the monitoring period.

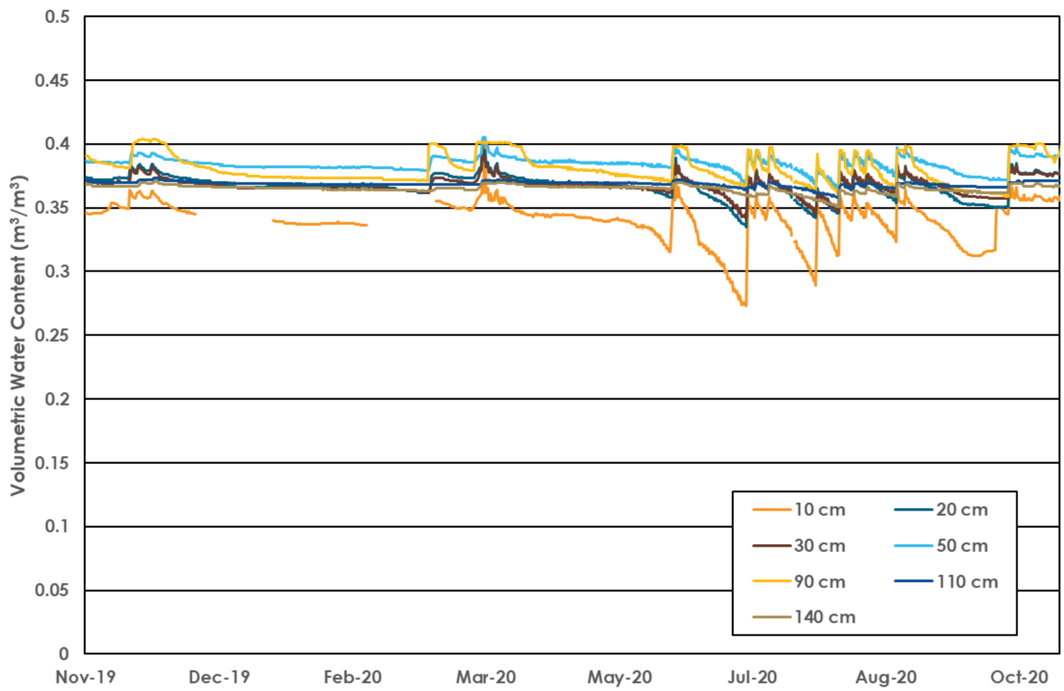

Figure B.3: VWC profile at Trial #2 Primary Station during the monitoring period.

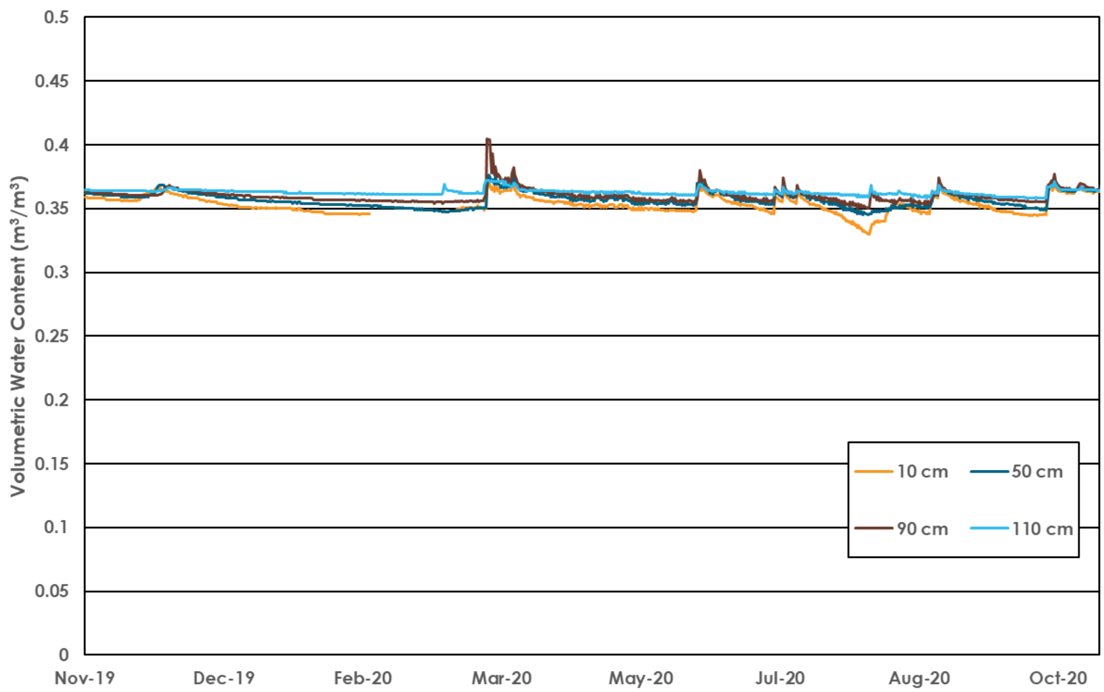

Figure B.4: VWC profile at Trial #2 Secondar Station during the monitoring period.

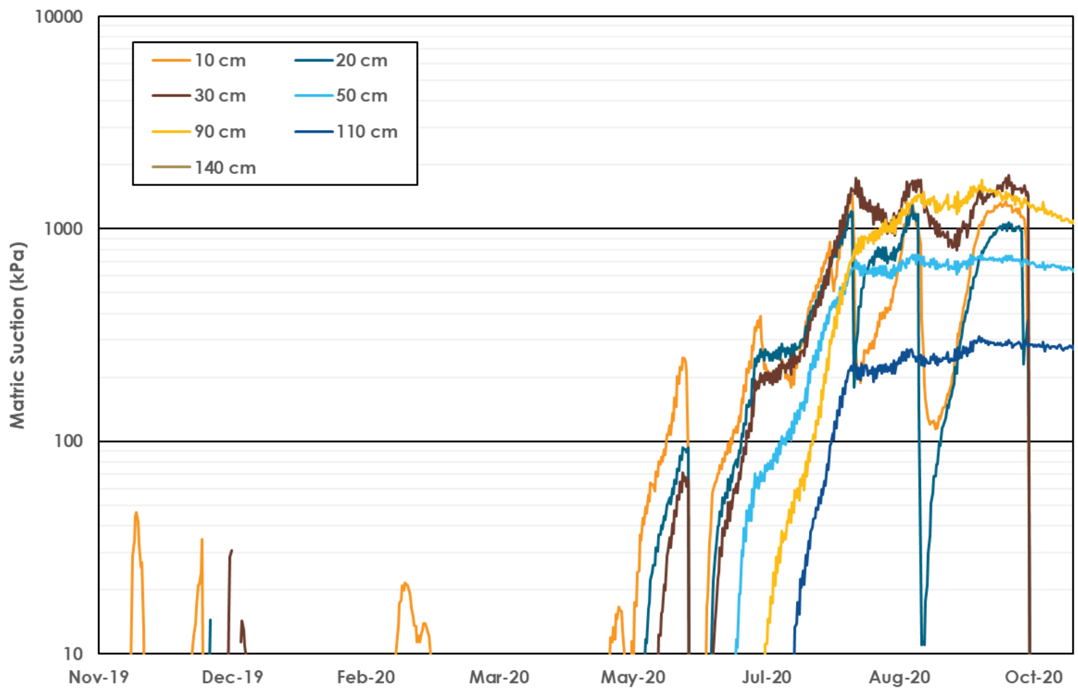

Figure B.5: Suction profile at Trial #1 Primary Station during the monitoring period.

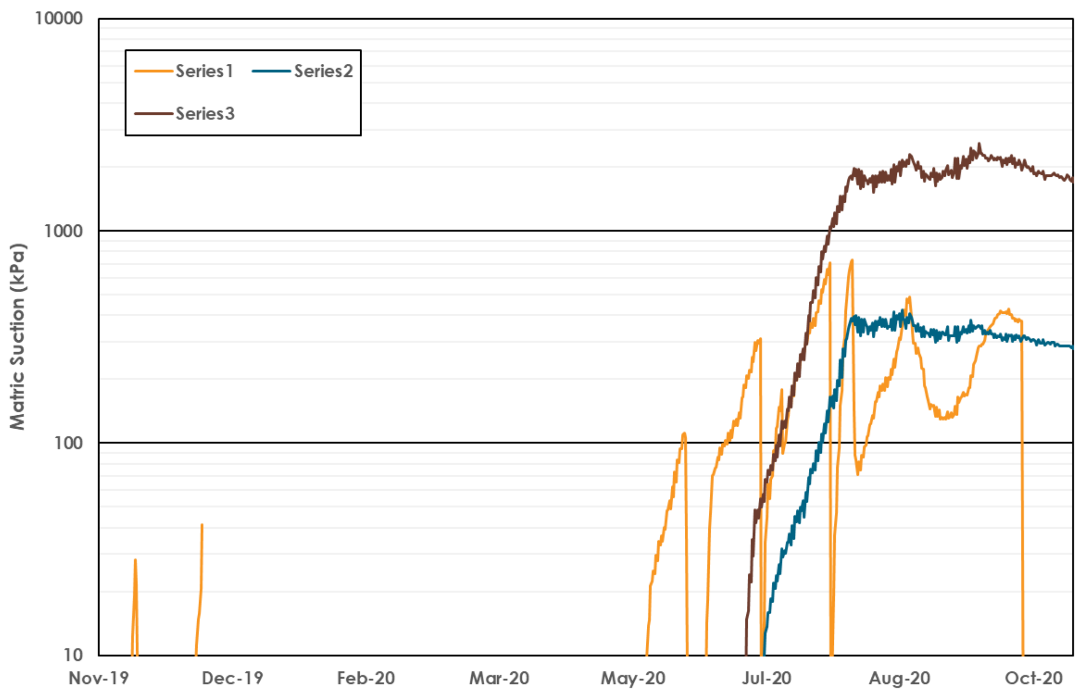

Figure B.6: Suction profile at Trial #1 Secondar Station during the monitoring period.

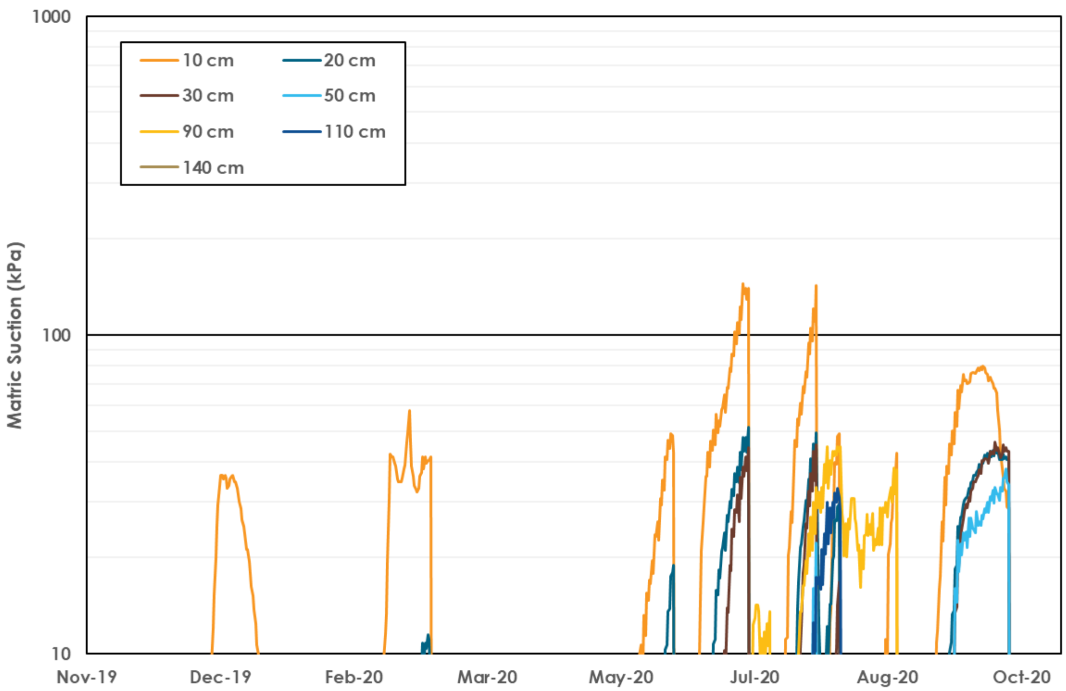

Figure B.7: Suction profile at Trial #2 Primary Station during the monitoring period.

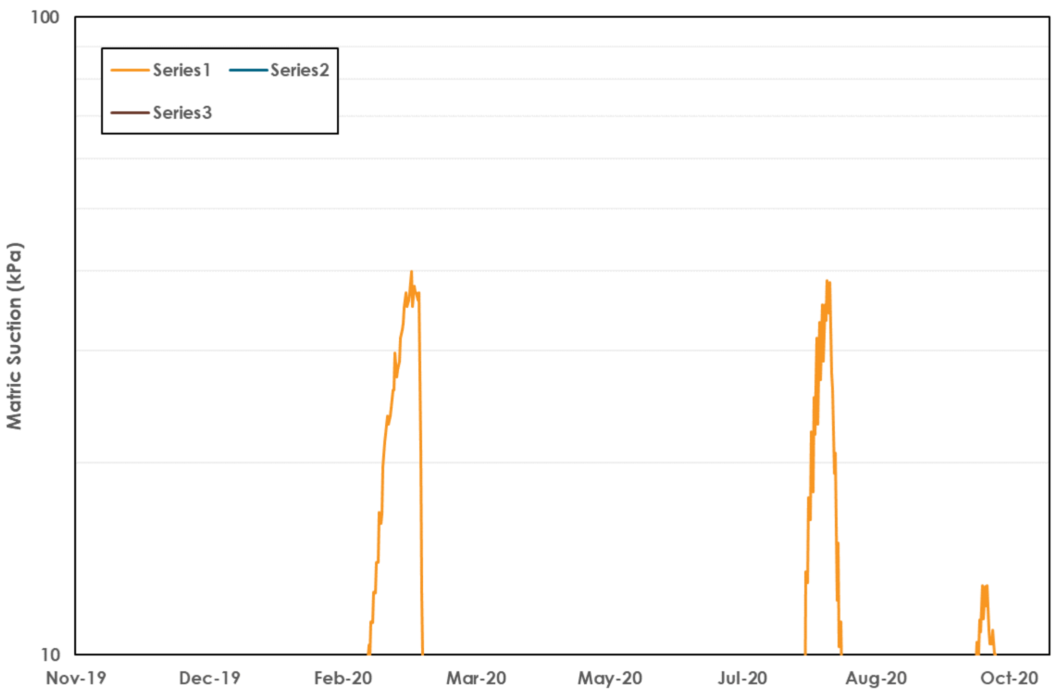

Figure B.8: Suction profile at Trial #2 Secondar Station during the monitoring period.

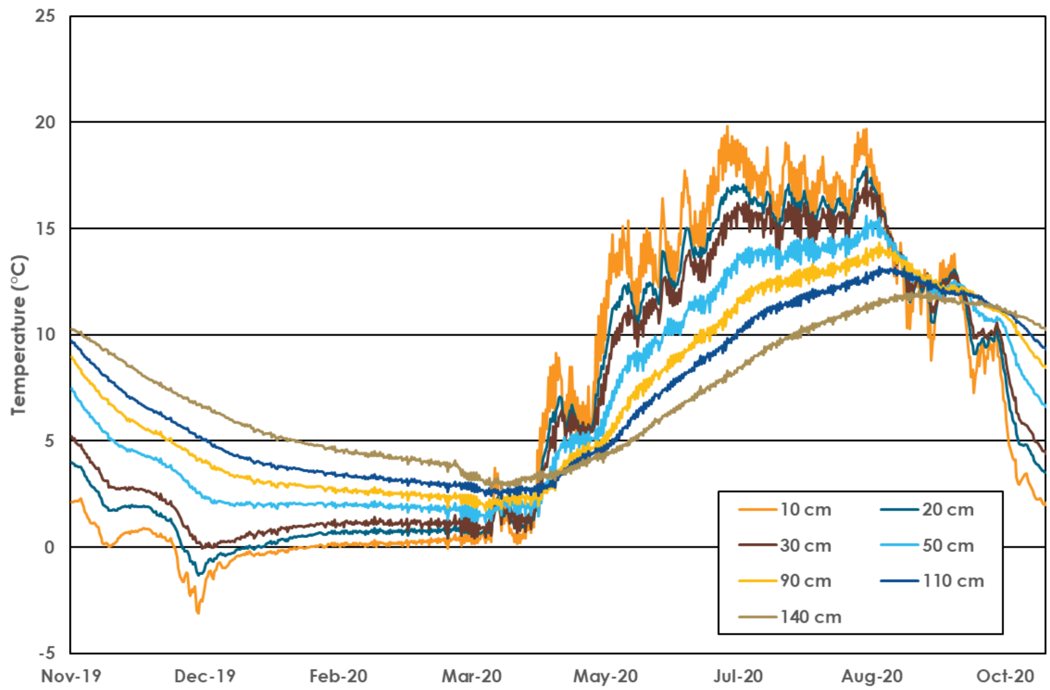

Figure B.9: Temperature profile at Trial #1 Primary Station during the monitoring period.

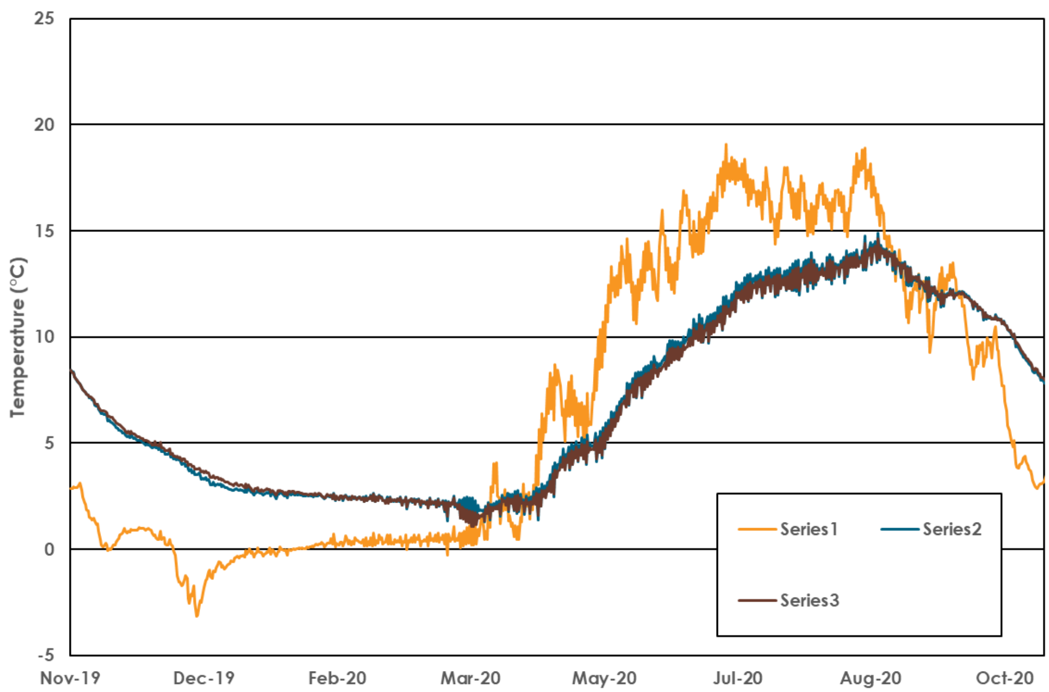

Figure B.10: Temperature profile at Trial #1 Secondar Station during the monitoring period.

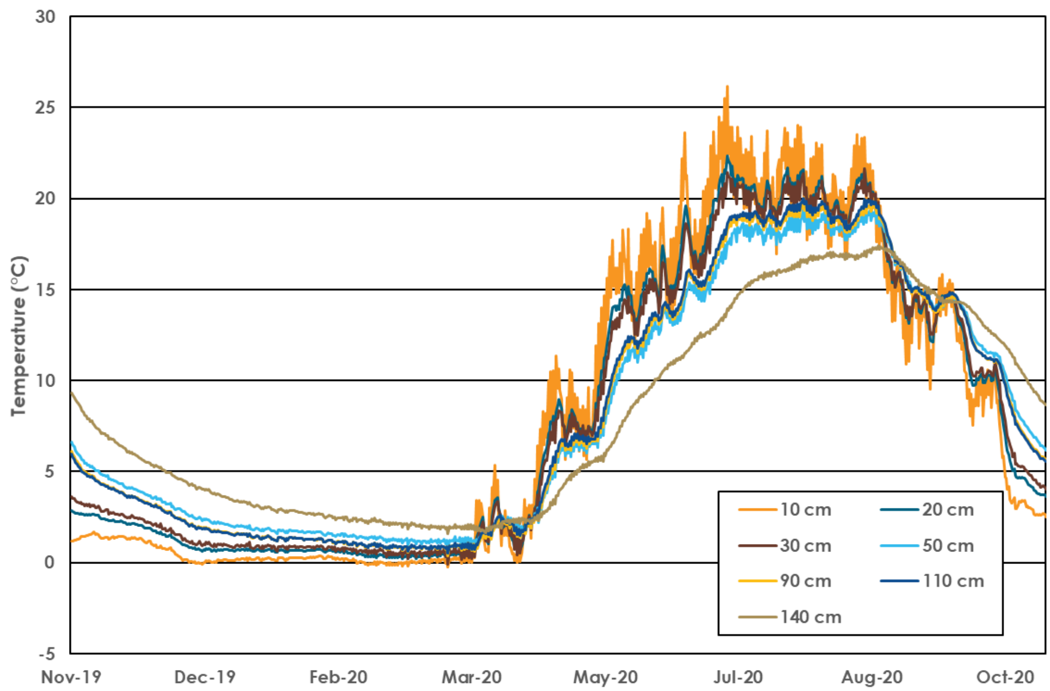

Figure B.11: Temperature profile at Trial #2 Primary Station during the monitoring period.

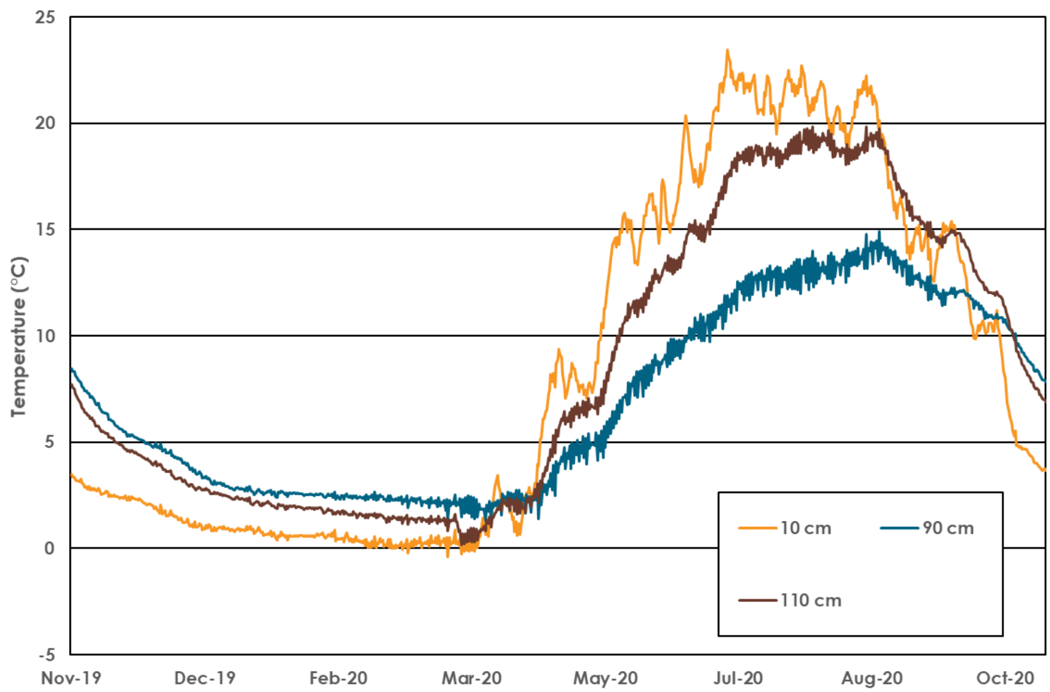

Figure B.12: Temperature profile at Trial #2 Secondar Station during the monitoring period.