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Evaluating the performance of a high density polyethylene lined cover system at the reclaimed Franklin Mine near Sydney, Canada

G. Meiers *O'Kane Consultants Inc., Canada*

M. O'Kane *O'Kane Consultants Inc., Canada*

D. Mayich *Enterprise Cape Breton Corporation, Canada*

Abstract

Enterprise Cape Breton Corporation (ECBC) has implemented a remediation programme for the Franklin coal mine located near Sydney, Nova Scotia, Canada. Waste rock generated from the Franklin mine and ten other mines in close proximity, all of which operated from 1885 to 1959, were consolidated into the Franklin waste rock pile (WRP). The waste rock is acid generating with the potential to continue to generate acid rock drainage (ARD). A cover system was constructed over the Franklin WRP in the fall of 2010 with the overall objective to minimise detrimental impacts of the mine waste on the receiving environment in the short term and facilitate recovery of the environment disturbed by mining over the long term.

The Franklin WRP cover system consists of a geotextile fabric, engineered 60 mil high density polyethylene (HDPE) geomembrane, a geocomposite drainage layer, and 600 mm of glacial till. Instrumentation was installed during construction of the cover system to facilitate evaluation of its performance over time under site-specific climate conditions. The primary objective of the monitoring programme is to develop a database of cover system moisture and thermal field responses, as well as internal WRP dynamics and groundwater conditions within the WRP footprint, for eventual calibration of a soil-plant-atmosphere numerical model and groundwater flow and contaminant transport model. The modelling effort would ultimately be capable of developing predictions and further understanding of long-term cover performance in limiting impacts to the receiving environment.

The WRP performance monitoring system is detailed within this paper along with preliminary performance of the cover system. This paper provides unique insight into developing an understanding for the change in waste rock pore-water chemistry and waste rock pile seepage quantity and quality as a result of placing a low permeability cover system over a full-scale waste rock pile in a seasonally humid environment. The challenges and solutions for developing a performance monitoring system for a full-scale cover system that incorporates a low permeability cover system are also discussed.

1 Introduction

The application of a dry cover system over reactive waste rock is a common technique for preventing and controlling acid mine drainage following closure of a mine waste storage facility. Dry covers can be simple or complex, ranging from a single layer of earthen material to several layers of different material types, including native soils, non-reactive tailings and/or waste rock, geosynthetic materials, and oxygen consuming organic materials. Cover system field monitoring is an essential and necessary method for evaluating performance of cover systems and provides a direct method of verifying the design of the cover system. Field performance monitoring can be implemented during the design stage with test cover plots (Aubertin et al., 1997; O'Kane et al., 1998a, 1998b), or following construction of the full-scale cover (MEND, 2004a; MEND, 2004b); O'Kane et al., 1998c). Direct measurement of field performance of a cover system is the best method for demonstrating performance to stakeholders and developing further understanding for long-term cover system performance.

The primary purpose of cover systems is to minimise any deleterious impact of the mine waste on the receiving environment in the short term and to facilitate recovery of the environment disturbed by mining over the long term. The impact of a waste storage facility on the receiving environment will depend on the nature of the site, climate, characteristics of the waste, local hydrogeology, and the ability of the cover system design to limit the release of contaminants of concern from the underlying waste. As a result, one of the primary design objectives of a cover system for waste storage facilities is to limit percolation of water into the underlying waste (O'Kane and Barbour, 2003). This is generally achieved through the use of a low permeability layer and/or a moisture store-and-release layer (MEND, 2004a). Subsequently, net percolation (NP) from the base of the cover system into the underlying waste material is a key measure of cover system performance.

Even though NP is a critical cover system performance monitoring parameter, a monitoring programme should be designed to measure the various components that influence the performance of a cover system. These components are shown schematically in Figure 1 and are comprised primarily of the elements of the water balance, oxygen flux, and climate. MEND (2000); providing a detailed overview of field performance monitoring for cover systems. In terms of field performance monitoring for a full-scale cover system, a recommended minimum level of monitoring would include meteorological monitoring, such as determination of the potential evaporation (PE) and site-specific precipitation, cover material moisture storage changes, watershed or catchment area surface runoff, vegetation, and erosion (MEND, 2004b).

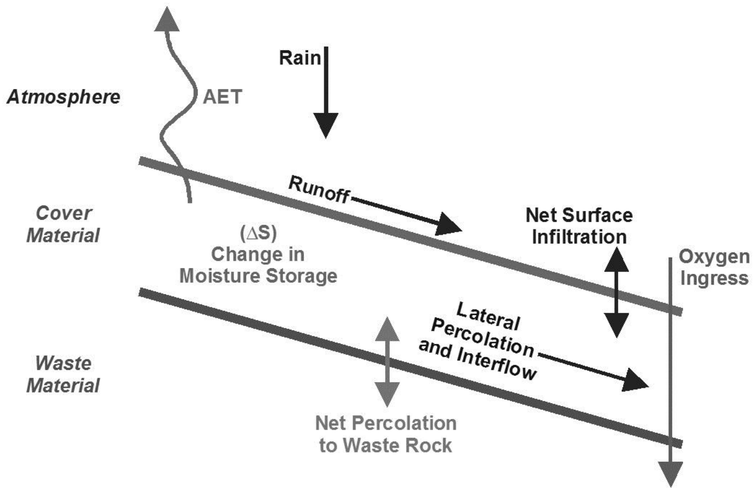

Figure 1 Components that influence the performance of a cover system

Field performance monitoring programmes, which focus on water quality analyses of seepage discharged from the waste storage facility, empirically describe a waste storage facility through monitoring of its cumulative effect at the base. This approach has two major disadvantages. The first is that it may take tens if not hundreds of years before a considerable change is measured inside or downstream of the waste storage facility due to, for example, drain-down effects, complete oxidation of sulphidic minerals, and/or mixing with groundwater. The second disadvantage is that without additional forms of monitoring, there will not be sufficient information to explain the results if they do not meet expectations. Therefore, this monitoring approach on its own does not provide enough information for understanding and predicting performance of a cover system placed on the waste storage facility to mitigate acid rock drainage (ARD) (O'Kane, 2011).

In terms of composite covers, which include a geomembrane layer (polymeric sheets), water and oxygen can move through the geomembrane by diffusion, but the transmission rates are very low. In general, the hydraulic conductivity corresponding to water diffusion is of the order of 10–12 to 10–15 cm/s (Giroud and Bonaparte, 1989). Considering that geomembranes are perceived as being essentially impervious when devoid of defects, performance monitoring programmes are not traditionally implemented for cover systems that include a geomembrane. However, this rational is somewhat flawed in that NP alone does not define cover system performance. For example Ayres et al. (2004) highlighted the importance of the growth medium in providing protection to a low flux barrier layer against physical, chemical and biological processes. An improperly designed growth medium layer may not adequately protect the barrier layer, leading to possible changes in its performance (INAP, 2003). As well as providing protection to the barrier layer, the growth medium should provide for a stable landform and the establishment of sustainable vegetation (MEND, 2004a). Holding on to the conceptual design of an impervious geomembrane, the longevity of the geomembrane and subsequent long-term performance will be a function of the performance of the growth medium.

Darilek et al. (1989), Giroud and Bonaparte (1989), Brennecke and Corser (1998), and Rollin et al. (1999) reported that even with recent advances in the testing and installation of geomembranes they are almost never installed without defects. Benson (2000) found that the effective saturated hydraulic conductivity of geomembranes may be several orders of magnitude greater due to defects. The primary factors leading to defects in geomembranes, resulting in a reduction in performance are: 1) inadequate welds and attachments to structures; 2) imposed stresses and mechanical damage during construction; and 3) service stresses that induce stress cracking at points of stress and weld separation. Except for poor welding and damage induced during installation, geomembranes generally only fail by stress cracking (performance characteristic of HDPE), or as a combination of oxidation followed by stress cracking (Peggs, 2003). Should defects in the geomembrane exist due to deleterious impacts, both as-built and post construction, a growth medium, overlying layers designed with an optimum moisture store-and-release capacity, as well as an ability to properly manage lateral percolation above the geomembrane (interflow) will mitigate moisture fluxes to the underlying waste material.

Direct monitoring of cover system performance will allow for predictions of performance under long-term normal climatic and extremes conditions in response to changes to the as-built condition to both the growth medium and geomembrane. Subsequently, the implementation of multi-disciplinary monitoring programmes is critical for developing an understanding of current and long-term cover system performance.

2 Background

The reclaimed Franklin WRP is located at the former Franklin mine site in Bras d'Or, N.S, Canada. As part of the Franklin Group of Properties remediation programme, approximately 187,000 m^3 of historic coal waste materials (waste rock) from the Franklin mine site and other nearby sites (Colonial No. 1, Colonial No. 4 and the Atlantic mine sites) were removed, relocated and consolidated in the Franklin WRP. The consolidated waste rock is currently acidic with the potential to continue to generate ARD (Phase, 2010).

The Franklyn WRP is sloped at a 4:1 (H:V) surface gradient and has a relatively small surface plateau at its apex. A perimeter ditch, which is divided into two flow directions, collects runoff from the landform surface with runoff generated in two surface water catchments. Runoff generated from the south catchment is directed southeast to the sediment pond adjacent to the eastern side of the pile, while runoff from the north catchment is directed north and then east towards the sediment pond. The WRP landform is approximately 2.5 ha with the south and north catchment approximately 1.05 and 1.45 ha, respectively.

The cover system design was developed by an engineering consulting team consisting of ADI Ltd., Stantec Inc., CBCL and SENES Consultants Ltd. Hazco was the contractor on site for construction of the cover system, which occurred between June 2010 and November 2010. The WRP was reclaimed with a geotextile fabric, HDPE geomembrane, geocomposite drainage layer (GDL), and 600 mm of imported glacial till to serve as a growth medium (see Figure 2). In addition, two 150 mm HDPE riser pipes or exhaust vents were installed through the cover and HDPE on the top of WRP to provide for degassing.

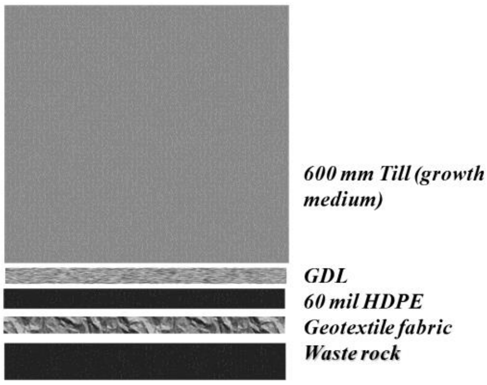

Figure 2 Franklin WRP cover system design

A multi-phase, multi-discipline monitoring programme was implemented in support of evaluating the performance of the reclaimed Franklin WRP and to achieve the following objectives:

- Obtain a water balance for the site, and more specifically, for the cover system itself.
- Identify and characterise key mechanisms and processes that control performance.
- Track the evolution of cover performance in response to site-specific physical, chemical and biological processes.
- Obtain a representative set of field performance monitoring data to calibrate a soil-plant-atmosphere numerical model and ultimately predictions of long-term cover performance.
- Link a groundwater contaminant transport numerical model to a soil-plant-atmosphere numerical model for predictions of impacts of contaminant release from the WRP on the receiving environment.
- Develop confidence with all stakeholders with respect to closure performance of the WRP.

3 Reclaimed waste rock pile – performance monitoring system

The Franklin WRP performance monitoring system includes a meteorological station, a v-notch weir for measuring runoff flows and interflow, four automated stations for measuring in situ moisture and pore-gas concentrations above and below the cover system. In addition, three systems were installed to allow for monitoring of the WRP internal conditions. The instrumentation, shown in Figure 2, was installed and commissioned as of 24 October 2010, with the exception of the weir data acquisition system (DAS), which was installed by ECBC in March 2011. OKC (2011) provides a complete record of installation.

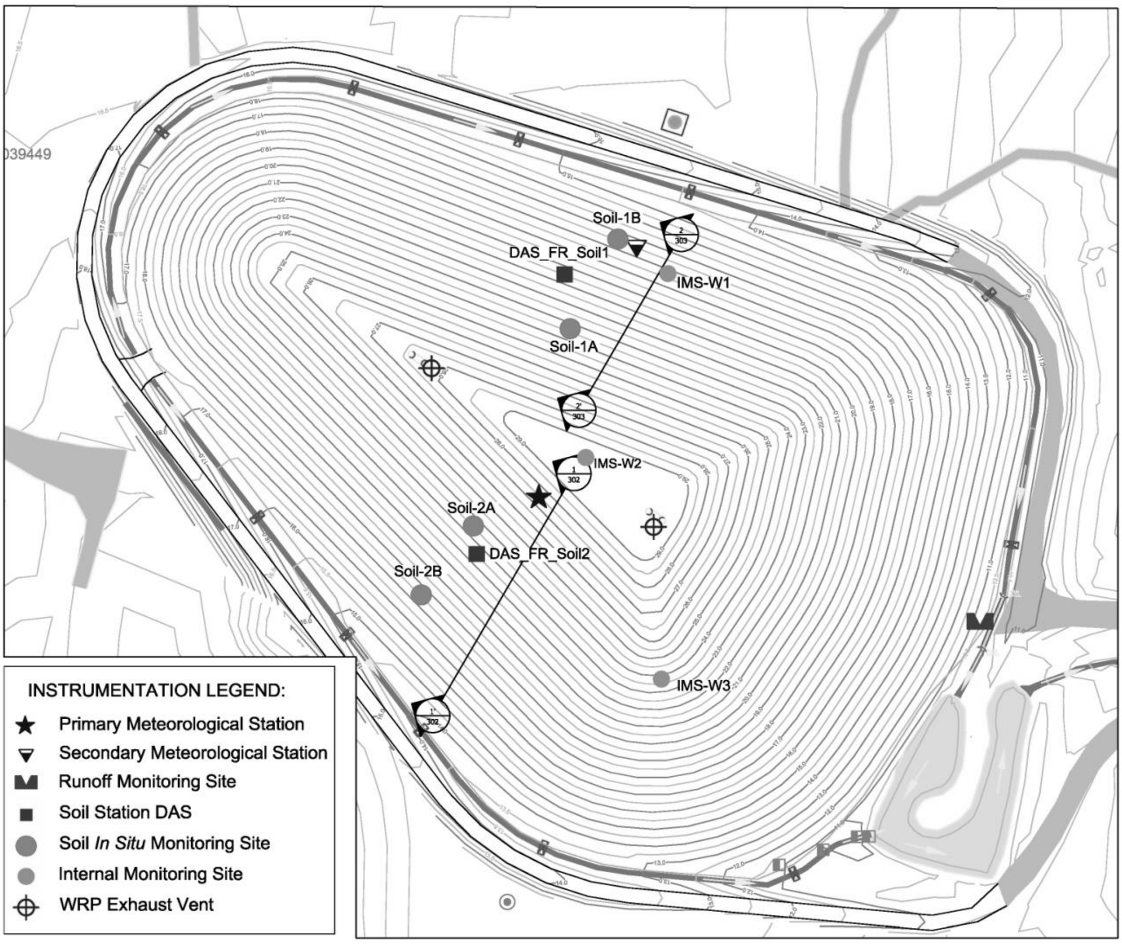

Figure 3 Location of monitoring stations on the reclaimed Franklin WRP cover system

Campbell Scientific data acquisition systems (DASs) were utilised for the project to provide a robust monitoring system and research grade measurements. The DASs interface with a variety of open protocols and can therefore collect data from a range of monitoring sensors.

A fundamental design feature of a field performance monitoring system is that the presence of the monitoring system components and installation procedures must not influence the data being collected. To ensure the monitoring system did not compromise the HDPE layer, all instrumentation and sensor leads were passed through a PVC pipe which was sealed to the HDPE with a boot assembly. The inside of the pipe was then sealed with an epoxy resin to mitigate gas and water fluxes across the cover system.

3.1 Meteorological station

A fully-automated meteorological station was installed near the crest on the south slope. The station measures air temperature, relative humidity, wind speed and direction, net radiation, rainfall, barometric pressure and snowpack depth. Sufficient monitoring is in place to allow potential (or theoretical maximum) rates of evaporation from the cover surface to be determined using the Penman (1948) method. Given the anticipated differences in incident solar radiation, an additional net radiometer was installed at a north slope monitoring location.

3.2 In situ moisture conditions

Thermal conductivity (TC) and time domain reflectometry (TDR) sensors were installed into a trench excavated into the waste rock and cover profile. The waste rock and cover material backfill was placed in lifts and compacted with the excavator bucket and by tracking the excavator across the surface. The use of traffic compaction was utilised to create a similar density condition to the surrounding in situ material, which was compacted in a similar manner with traffic compaction. The methodology selected for backfilling the sensor trench was based on the in situ water content of the cover material and waste rock. Sufficient moisture existed in the backfill materials to provide a plastic behaviour under compaction, allowing it to form around the sensors creating intimate contact with the in situ material. Typically, at water contents below the plastic limit, sensors are installed in an undisturbed face within the excavation to minimise sensor damage while providing the required in situ conditions.

Cover system performance will be different along the slope profile of the WRP as a result of higher surface runoff and lateral diversion of subsurface waters on the slopes. In addition, slope aspect will have an influence on cover system performance due to differences in incident solar radiation and resulting snowpack formation and melting period, rates of evapotranspiration, and vegetation development. To accommodate for the variety in moisture dynamics, four (4) soil monitoring stations were strategically positioned across the WRP to develop a thorough understanding for the cover system moisture regimes on a temporal and spatial basis.

The TC and TDR sensors were installed at the same depth in close proximity to one another in the cover and waste rock profile to enable development of field moisture retentions curves (MRC), and field hydraulic conductivity functions (k-functions). The field measured MRC and k-function is a parameter input to the soil-plant-atmosphere numerical model, which will ultimately be utilised for simulating measured field performance. Figure 4 is a schematic of a soil monitoring station located on the Franklin WRP.

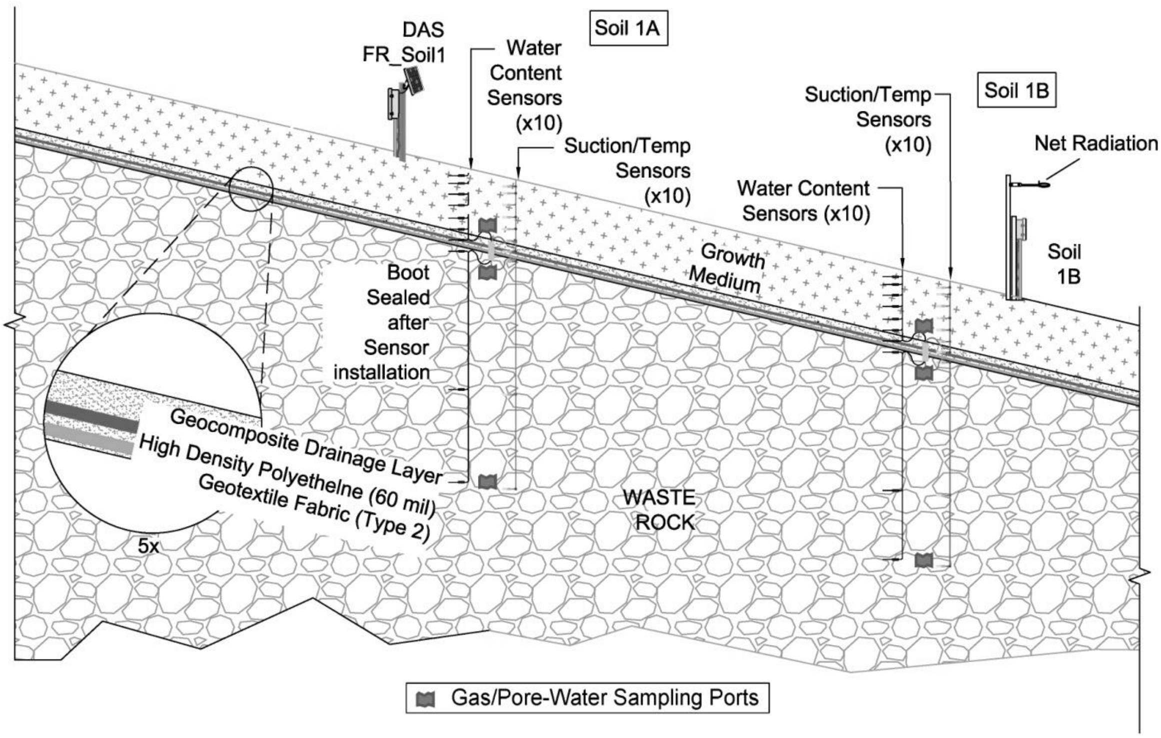

Figure 4 Schematic of the Franklin WRP soil monitoring station

3.3 Internal monitoring system

The characteristics of ARD that develop, such as low pH and elevated concentrations of dissolved elements, are influenced by, but not limited to, the in situ moisture content and the ingress of meteoric water, as well as transport of gases (e.g. oxygen) across the cover system (exiting and entering the waste material). The mass or load of contaminants released from the WRP to the receiving environment will be a function of cover system performance (i.e. NP), change in water storage within the waste facility/material, characteristics of the waste and the concentration of solutes within the seepage. Hence, monitoring of internal WRP conditions is critical for predicting impacts to the receiving environment.

One of the design objectives of the cover system and HDPE layer in particular is to limit oxygen fluxes into the underlying reactive waste rock. The migration of oxygen to the underlying waste will be minimised by maintaining the integrity of the HDPE layer. Gas can move across the cover system by diffusion and advection processes. Diffusion is the movement of molecules or ions from a region of higher concentration to one of lower concentration as a result of random Brownian movement. An advective process is one in which oxygen may be carried along with air or water moving through a WRP.

Respiration through a WRP will largely be influenced by the dynamic interaction between internal and external pressure and temperature conditions. The reaction of oxygen with sulphide minerals releases heat, as does the reaction of carbonate minerals with acidity. An increase in gas temperature causes it to expand and become less dense and when the gas becomes warm enough and light enough in relation to the external conditions, it will start to rise (Phillip et al., 2009). Changes in oxygen and carbon dioxide content can also affect the density of the pore-gas and can lead to the same effect as temperature change (Hockley et al., 2009). For example, oxygen is one of the heavier components of air, so its depletion within the pore-gas tends to make it lighter.

The two potential pathways for oxygen ingress into the Franklin WRP would include diffusion across the cover layer and respiration (i.e. advection) through defects in the HDPE layer and exhaust vents located on the upper surface. In order to develop an understanding of pore-gas dynamics within the WRP three internal monitoring systems (IMSs) were installed in the Franklin WRP to allow for:

- Automated monitoring of pore-gas pressure and temperature.
- Manual monitoring of ground water levels and pore-gas concentration.
- Collection of pore-water for geochemical analysis.

The IMS consists of a well, instrumented with four temperature probes and continuous multi-channel tubing (CMT). The CMT is a polyethylene tube segmented into seven (7) channels, which allows for sampling along the profile at isolated depths. Sampling ports were installed at each of the soil monitoring stations to allow for collection of pore-water and/or pore-gas samples within the cover profile and within the waste rock approximately 0.1 and 2.0 m below the HDPE layer. In addition, differential pressure is monitored within the exhaust vent to evaluate gas fluxes from the structures.

3.4 Net percolation

There are a variety of ways of estimating NP depending on the range of data that is available for the site. A methodology that incorporates several monitoring methods of estimating NP is advantageous in that a more comprehensive understanding of cover system performance can be developed (Meiers et al., 2009). NP from the base of the reclaimed Franklin WRP cover system will be:

- Estimated utilising measured components of the water balance and in situ hydraulic gradients (analytical method).
- Simulated using soil-plant-atmosphere numerical models that have been calibrated to measured field responses.
- Estimated using a conservative tracer.

3.4.1 Analytical method

A simple water balance can be completed for a cover system using the performance monitoring data collected at the site. The water balance for a sloping cover system consists of the following components (also see Figure 1):

$$PPT = R + AET + NP + \Delta S + LP \tag{1}$$

where: PPT is precipitation, R is surface runoff, ΔS is the change in water storage within the cover material, AET is the actual evapotranspiration, and LP is lateral percolation or interflow. NP is then back-calculated as the residual based on measurements or estimates of the other components of the water balance.

It is essential that as many components of the water balance are measured as possible because NP rates are often a small component of the water balance, particularly in the case cover systems that include an HDPE layer. ECBC has procured an Eddy covariance (EC) system, which will be rotated between the Franklin site and three other waste storage facilities to provide direct measurements of AET. Utilisation of an EC system to measure AET is “best practice” because it allows for all but one component of the cover system water balance to be measured for the monitoring programme. In the absence of an EC system, analytical estimates of AET can be developed based on components of the water balance, hydraulic gradients, and meteorological parameters.

3.4.2 Numerical model simulations

Field monitoring of cover system performance provides a data set for calibration of simulation models. The minimum level of field monitoring required for calibration of the numerical model includes meteorological monitoring of precipitation along with sufficient monitoring to estimate PE, changes in cover water storage, and surface runoff. It is important to monitor over multiple years in order to observe cover performance for a range of climatic conditions, thus increasing confidence with the numerical simulations.

In general, numerical models used in cover design are one or two dimensional finite element models that predict pressure head (suction) and temperature profiles in the cover profile in response to climatic forcing (such as evaporation). A key feature of these models is the ability to predict AET based on PE, vegetation parameters and soil suction. Parameters required by the model include climate data to characterise the soil-atmosphere boundary condition, material properties (particularly the functional relationships between volumetric water content and hydraulic conductivity as a function of suction), and vegetation characteristics (rooting depth/distribution and leaf area).

Prediction of long-term cover system performance due to varying climatic conditions, geometry, and material properties would be completed using the field calibrated model. In addition, models calibrated to measured performance would be used to develop a cause affect relationship for varying degrees of post construction defects in the HDPE layer. This would be accomplished by calibrating the model to measured performance and then substituting the pressure condition measured at the base of the HDPE layer to the base of the geocomposite drainage layer ,i.e. remove the HDPE layer from the numerical simulation. Outcomes based on the aforementioned numerical simulations will provide stakeholders with an understanding of potential liabilities and adverse impacts to the receiving environment associated with various HDPE layer performance scenarios.

3.4.3 Conservative tracer

Two conservative tracers were applied at the IMS sites to validate NP rates estimated through the analytical method and numerical simulations. Deuterium (D) and chloride (as sodium chloride, NaCl) were applied in September 2010. The tracers were applied to the waste rock surface on a 5 by 5 m area centred on each CMT monitoring well prior to placement of the HDPE cover layer. Water for the tracer tests was spiked to produce the required concentrations of deuterium and chloride. The delta D for the tracer is approximately +1,500‰ compared to background delta D (-100‰) in pore-water.

As changes in the ratio of D/H and Cl concentration would be primarily due to advection, the migration of the tracers within the waste rock can be used to estimate a NP rate between the time of applying the tracers and sampling for their migration. Samples will be analysed for concentrations of D and Cl using mass spectrometry and ion chromatography. Given that the D will equilibrate with water-vapour in the waste rock, sampling for D through the CMT can occur in the vapour or water phase, depending on the in situ moisture conditions at the depth of sampling. Given that it is anticipated that the flux of water across the HDPE layer will be low, sampling for D will occur annually with the first sampling period in September 2011. Sampling for Cl would only occur if the cover system was exhumed exposing the underlying waste rock.

3.5 Runoff and interflow

A zero-height V-notch weir structure was constructed to allow for measurement of flows in the perimeter ditch generated from the north WRP catchment. Sensors are used to automatically record the water level (stage) in the weir and temperature and conductivity of discharge waters. Given that the cover system HDPE layer extends into and underlies the perimeter ditch, both runoff and interflow volumes are channelled though the weir.

4 Cover system performance

Substantial amounts of data are being collected from the Franklin WRP cover performance monitoring system. Preliminary trends in performance monitoring data are presented in the section to address the objectives of this paper.

4.1 Atmospheric gas flux to the WRP

4.1.1 Pore-gas concentration measurements

Concentrations of O_2 and CO_2 were measured at the soil monitoring stations and IMS monitoring sites within the cover profile and underlying waste rock. During the oxidation of sulphide minerals, atmospheric O_2 (20.9% concentration) is consumed and CO_2 (0.03% concentration in atmospheric air) is produced when acidic pore-water generated as a result of the sulphide oxidation reacts with carbonates in the system.

Figure 5 presents pore-gas O_2 and CO_2 concentrations measured across the cover material and waste rock profile. The pore-gas concentrations were collected on 7 May 2011 and include data from the Soil-1B and IMS-W1 location. The O_2 pore-gas concentration was 20.7% at a depth of 40 cm within the growth medium and then decreases to 0.3% immediately below the cover layer. O_2 concentrations decrease along the waste rock profile form 0.3 to 0.1% to a depth of 4.7 m. The CO_2 concentration is 1.5% at 40 cm and increases to approximately 16% in the waste rock.

Prior to covering the WRP atmospheric O_2 was able to enter the upper waste rock profile via several mechanisms, including diffusion, barometric pumping, wind action, volume displacement during infiltration, and with infiltrating water containing dissolved oxygen. Subsequently, the pore-gas concentrations presented within this paper may be in part be due to oxygen that entered the waste rock prior to cover placement and O_2 transport across the cover system. Continued monitoring of pore-gas concentrations in the cover and waste rock profile will be a key set of data for developing an understanding for the O_2 flux across the cover profile.

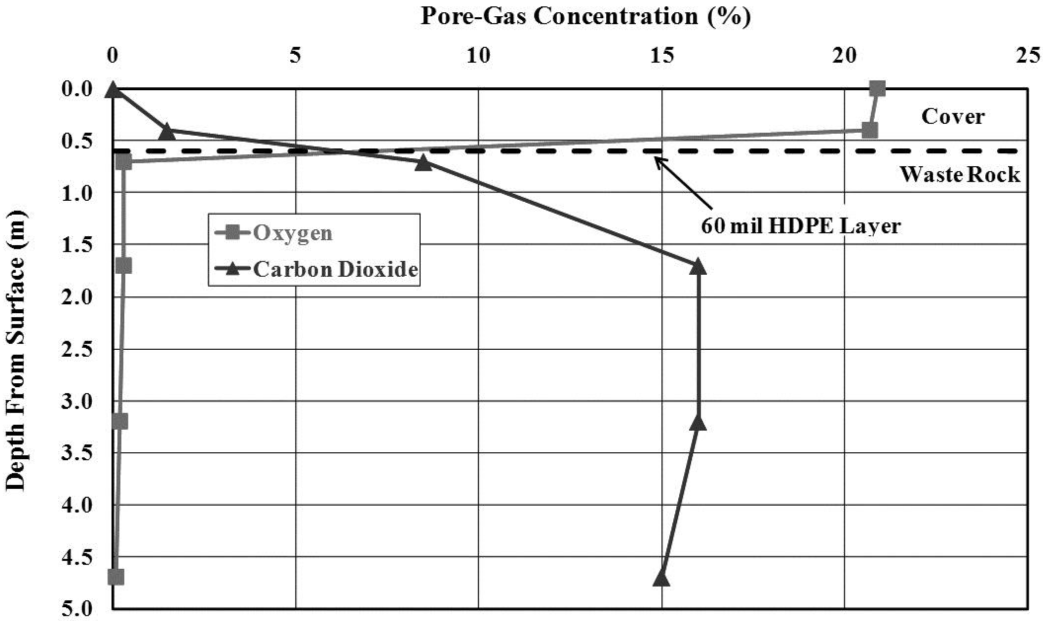

Figure 5 **O_2 and CO_2 pore-gas concentrations measured across the cover/waste material interface and the underlying waste rock**

4.1.2 Barometric pumping

Oscillations in barometric pressure are both diurnal, corresponding to daily heating and cooling of the atmosphere, and seasonal, resulting from the passage of weather fronts. When the barometric pressure rises, fresh surface O_2 enriched air is driven into the soil; however, when the barometric pressure drops, soil air vents upward into the atmosphere. The total movement of soil air is dependent primarily on the magnitude and period of the pressure oscillations, the soil permeability to air and cover homogeneity, and depth to an impermeable boundary.

Figure 6 shows the difference in air pressure measured between the barometric pressure (atmosphere) and air pressure at the base of the exhaust vent located at the top of the WRP in February 2011. Changes in barometric pressure are also included in Figure 6 for the monitoring period. An upward and downward advective flux is defined by a negative and positive differential pressure, respectively. The trend in differential pressure indicates a predominately upward flux from the WRP vent, with the differential pressure fluctuating from approximately -0.015 to 0.04 kPa for the monitoring period.

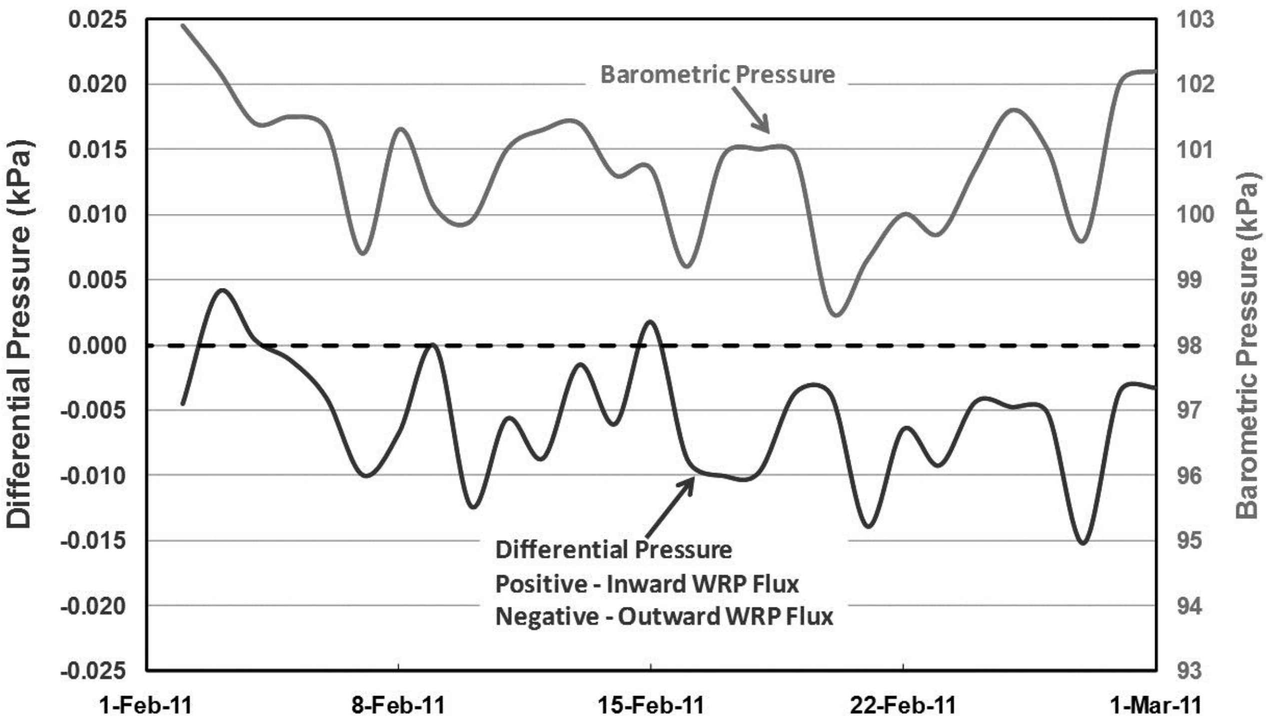

Figure 6 Changes in differential pressure measured across the WRP exhaust vent in relation to changes in barometric pressure

The changes in differential pressure to some extent replicate the change in barometric pressure, suggesting that the cover system is susceptible to barometric pumping. For example, an increase in barometric pressure tends to result in a more positive trend in the differential pressure. In general, the advective flux is upward out of the WRP. Barometric pumping, in terms of a homogeneous cover system, is typically not a significant factor influencing WRP respiration; however, it is more pronounced in conditions where flow is concentrated, such as that which would occur through exhaust vents on a cover system with a HDPE layer.

Further insight into dump respiration will be gained following an analysis of the dynamic interaction between internal and external temperature conditions and changes in oxygen and carbon dioxide content. This will be achieved through data collected at the IMS locations in terms of internal temperature, pressure, and gas concentrations along the waste rock profile. It is anticipated that the flow dynamics may change over time and become more pronounced as the relatively fine textured waste rock drains, consolidates and develops structure.

4.2 Change in water storage measured with water content sensors

Figure 7 is a 2-D contour plot or the volumetric water content profile measured at Soil-1A and Soil-1B, respectively. Throughout the monitoring period slight differences exist in wetting and drying at the Soil-1A and Soil-1B cover profile locations due to atmospheric forcing, i.e. rainfall and evaporation. At the lower slope location (Soil-1B), the cover profile is at a saturated or near saturated condition during the autumn and winter of 2010 and then again following snowpack melt in April 2011. Water contents at the Soil-1B location maintain a higher degree of saturation than the upper slope location. This would suggest that the lower slope location is experiencing runon. In addition, the wetter condition at the surface and at the base of the cover compared to the midway depth (i.e. 30 cm) would suggest that the cover is being wetted from above (i.e. precipitation) and laterally due to interflow along the base of the cover system.

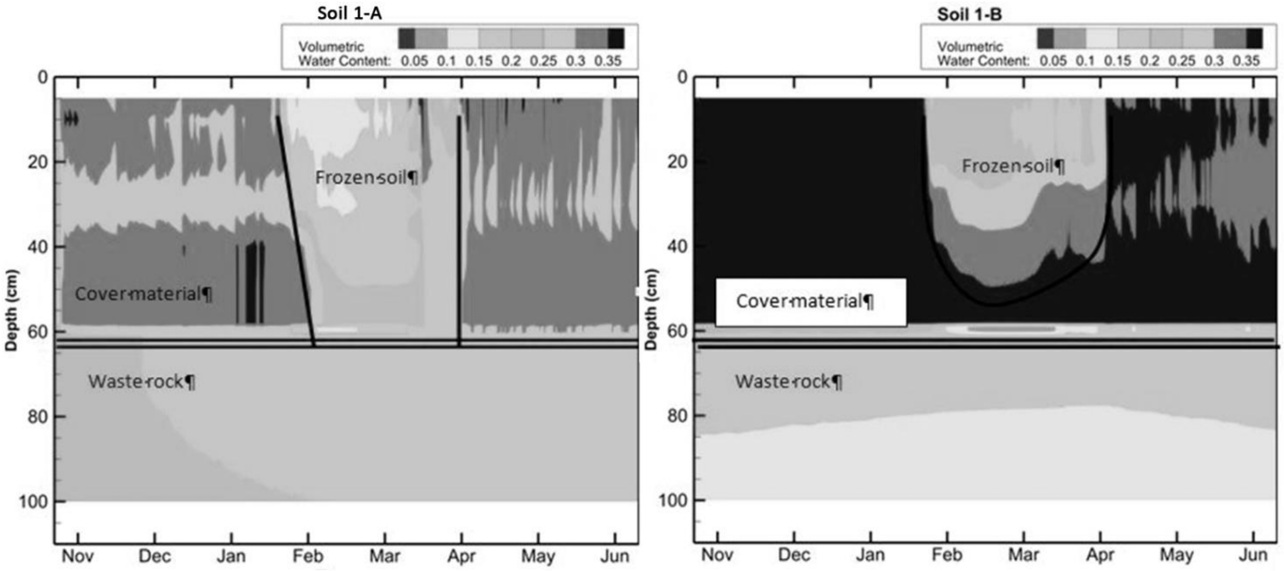

Figure 7 2-D contour of the Soil-1A and Soil-1B water content profile

The saturated conditions, in particular at the lower slope location may suggest that: 1) the cover profile is not full accessing the GDL; 2) the water transmission rate of the GDL may be insufficient to adequately drain water from the cover system profile; 3) the GDL is not draining at the toe of the slope; and/or 4) a capillary break may exist due to the textual contrast between the cover material and GDL.

The growth medium will initially exhibit a relatively low as built saturated hydraulic conductivity. Following wet-dry and freeze-thaw cycles the hydraulic conductivity of the cover system will increase to a post-construction condition (Benson et al., 2007; Meiers et al., 2006). This increase in saturated hydraulic conductivity of the growth medium layer may allow for a greater proportion of water to access the GDL and/or pass as interflow through the growth medium itself. Continued monitoring of moisture conditions in the cover profile coupled with interflow volumes estimated from the runoff collection system will allow for the GDL to be evaluated and an understanding for the hydraulic performance of cover system water dynamics to be developed.

5 Summary

Construction of the Franklin WRP cover system occurred between June 2010 and November 2010. The cover system is composed of geotextile fabric, engineered 60 mil HDPE geomembrane, geocomposite drainage layer, and 600 mm of glacial till. A state-of-the-art monitoring system was installed to assess field performance of the cover system during all seasons of the year. The system includes continuous monitoring of various climatic parameters, runoff and interflow, gaseous oxygen and carbon dioxide concentrations, pore-gas pressure, and moisture/temperature conditions within the cover and waste material. The system allows for determination of a water balance for the site and advective and diffusive oxygen fluxes to the underlying waste rock.

A preliminary review of key sets of field performance monitoring data would suggest that the moisture dynamics within the cover system will vary spatially across the cover profile and that WRP respiration, at the moment, is influenced by barometric pumping. On-going monitoring of the Franklin WRP will provide a unique dataset for the assessment of cover system performance under site-specific climatic conditions.

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