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31 August 2021

Our ref: 10003-L001Rev01

Dear Peter,

Former Marchon Site, Pow Beck Valley and area from Marchon Site to St Bees Coast, Whitehaven, Cumbria - Application for development of a new underground metallurgical coal mine to include a buried conveyor at Roska Park and Bellhouse Gill Woods and associated development ("the Proposal"): Illustration of potential impacts and mitigation

Please find below a summary of the potential issues that could occur as a result of the pipe-jacking "Trenchless Construction" method to be deployed at the above site in relation to the Proposal, and my findings on the mitigation principles for any potentially likely hydrogeological impact of those works. You will see from the letter attached from Mark McGeady (of The Joseph Gallagher Group) that in engineering terms he is satisfied that the principles of mitigation proposed in my note can be applied in practice.

You will note from the text and diagrams attached to this letter that I have taken a conservative approach to what might be encountered by way of existing ground conditions and have dealt with a number of speculative scenarios even though, in reality, there may be a good chance that there will be no issues at all. Based on my assessment and Mr McGeady's response, I am satisfied therefore that measures can be implemented as part of the proposed trenchless construction methodology to ensure that the pre-construction hydrogeological conditions will not be significantly impacted by the works, by which I mean that they will not result in:

1. the permanent or temporary loss of flow in the watercourse;
2. a pollution event; or
3. a sediment release that cannot be managed through standard control measures.

To further reduce the risks associated with the proposed construction, I would also recommend that construction is preferentially undertaken during periods when low or no flow might be expected in the gills.

In addition, I have had sight of a letter from Dr A D Martin of E3 Ecology dated 9 August 2021 addressed to a Maggie Mason of "South Lakes Action on Climate Change". I note from paragraph 17 of that letter that it is stated there is a "high risk of changing the drainage over a large area of ground, particularly downstream of the conveyor". In response to that statement I would comment as follows:

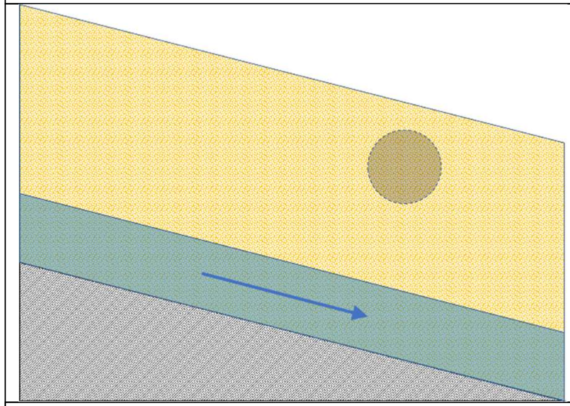
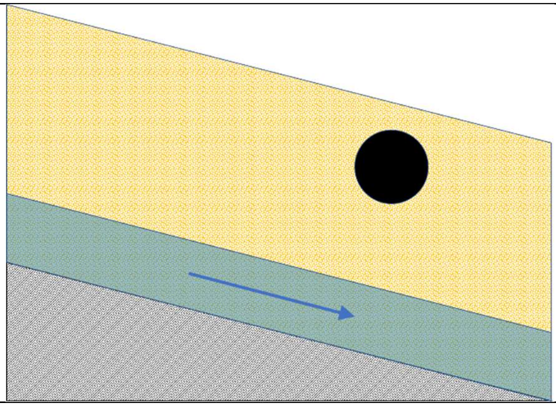
Whilst I acknowledge that the construction and presence of the proposed conveyor will have some effect on drainage and, potentially, groundwater flow, the important question is the degree, extent, and significance of the impact. The conveyor will be constructed approximately 2 m below the ground surface and, if located in the unsaturated zone (Scenario 1 in the attached assessment), the impact of this on vertical drainage and groundwater flow would be, in all likelihood, highly localised and insignificant. Downstream impacts would, in my opinion, be negligible and most likely imperceptible. The risk of significant impact is increased if the conveyor is constructed below the water table, but even under these conditions my opinion is that the circumstances where the impact would not be significant are far more likely that those where it would. Even under the less likely situation where impacts are significant, I believe that mitigation could be employed to reduce them to insignificant levels. I infer from Dr Martin's comments quoted above that he considers that the impacts are likely to be widespread and significant; I do not agree with this assessment and believe that the impacts are more likely to be localised and insignificant and, if ground conditions are encountered that may suggest otherwise, mitigable.

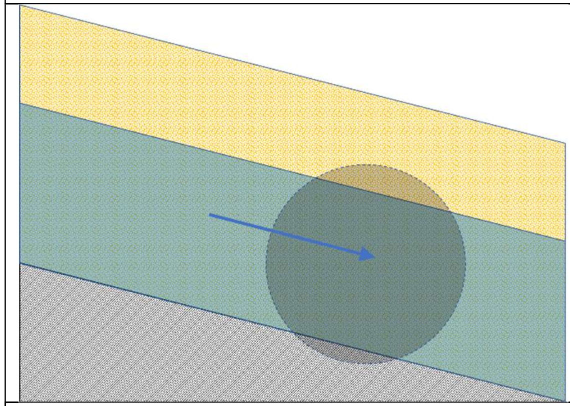
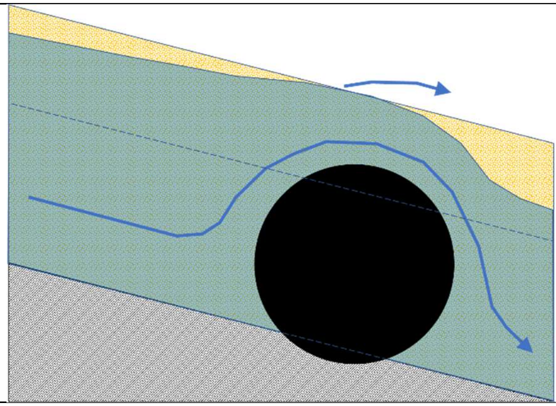
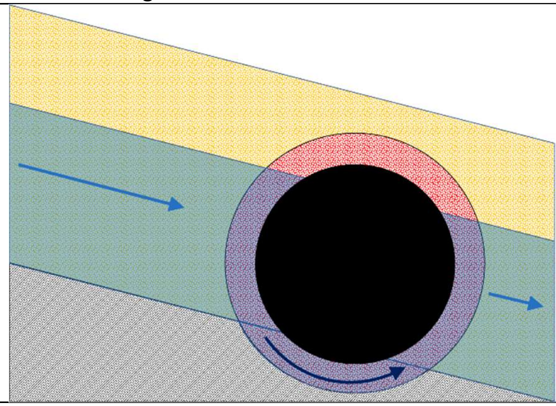
Yours sincerely

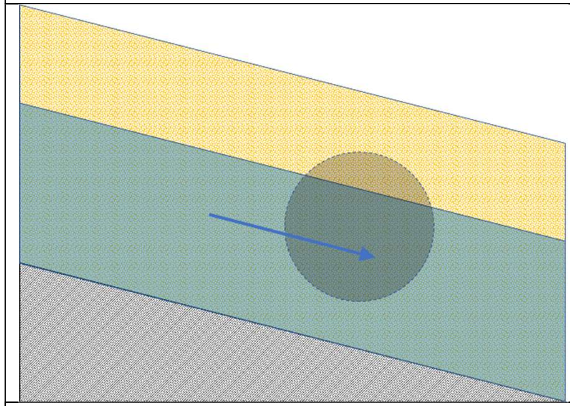
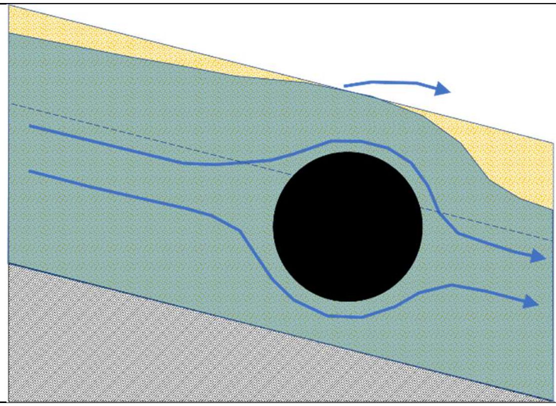
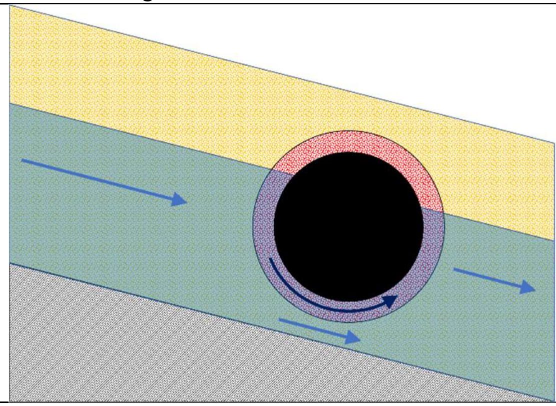
Barnaby Harding

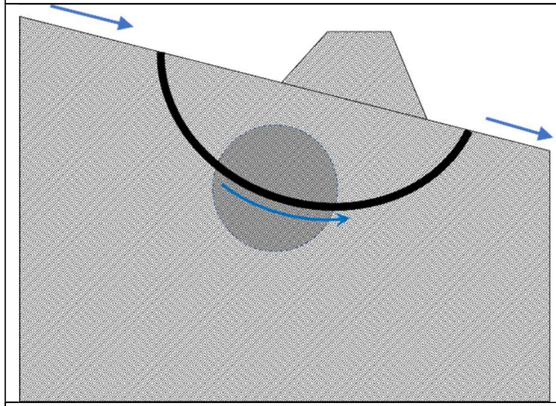
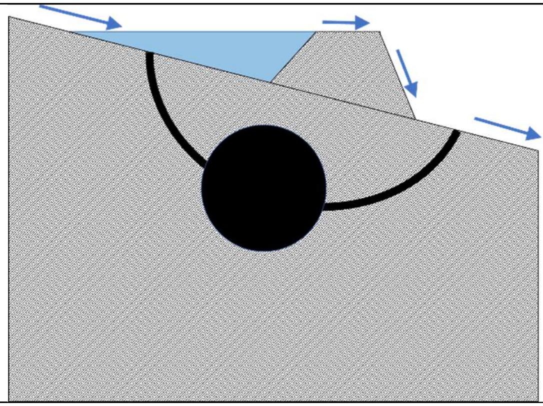
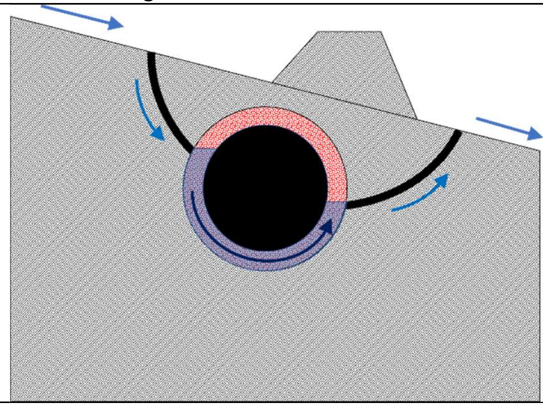
DIRECTOR

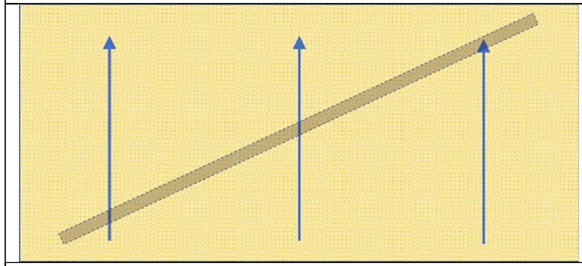
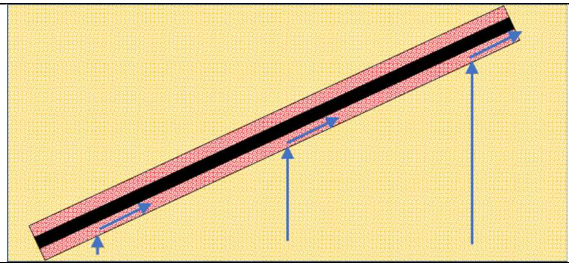
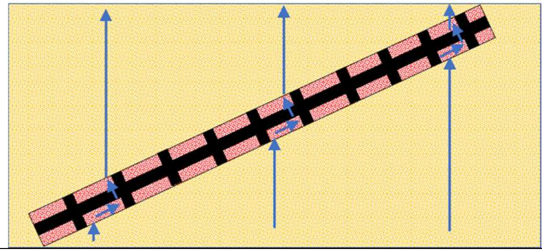
Encs

Scenario 1: Tunnel above water table		
Pre-construction Conditions	**Potential Post-construction Issue**	**Potential Mitigation**
		None required.
Water table (perched or regional) is located below tunnel invert. Based on currently available information this is likely to be the case if the tunnel is excavated through fill in Zone 1 and could be the case if the tunnel is excavated through solid geology and groundwater is deeper in Zone 1 and Zone 2.	None likely. Tunnel will be located in the unsaturated zone and will not impact on groundwater flows.	None required.

Scenario 2: Tunnel below water table (fully blocking)		
Pre-construction Conditions	**Potential Post-construction Issue**	**Potential Mitigation**
		
Pre-construction conditions as per Scenario 1 except that proposed tunnel would be partly or fully below the water table and occupy the full thickness of the unsaturated zone. This could be the case at Zone 1 and Zone 2.	Tunnel acts as impermeable block within aquifer and impedes groundwater flow. Groundwater will back up upgradient of the tunnel until it reaches a sufficient height to flow over the obstruction. If groundwater reaches the surface, waterlogging and groundwater breakout may occur. Dropping of downgradient groundwater levels less likely as total flow across the obstruction will ultimately remain unchanged unless there is a large amount of surface discharge.	Provide permeable pathway below tunnel. Water can continue to flow beneath the tunnel unimpeded and hence will not back up. Pathway could take the form of a jacket around the structure or a number of drains going beneath it, connecting the aquifer on the upgradient and downgradient sides.

Scenario 3: Tunnel below water table (partly blocking)		
Pre-construction Conditions	**Potential Post-construction Issue**	**Potential Mitigation**
		
Pre-construction conditions as per Scenario 1 except that proposed tunnel would be partly or fully below the water table but would not occupy the full thickness of the unsaturated zone. This could be the case at Zone 1 and Zone 2.	Tunnel acts as impermeable block within part of the aquifer and impedes groundwater, but not completely. Groundwater will back up upgradient of the tunnel until it reaches a sufficient height to reinstate pre-existing flow under (and possibly over) the obstruction. The degree to which this will occur will depend on the proportion of the saturated thickness which is blocked, the pre-existing groundwater gradient, and the width of the tunnel. For the proposed construction it is likely that a significant proportion of the saturated thickness would need to be blocked to result in a large increase in upgradient groundwater levels. As an example, for an initial saturated thickness of 4 m which is then reduced to 1 m (reduction to 25% of original thickness) at the location of the tunnel, a tunnel width of 5 m, and a pre-existing groundwater gradient of 1 in 50, the rise in upgradient water levels would be of the order of 0.3 m. If the saturated thickness is reduced to 0.4 m (10% of original thickness) the upgradient rise would be around 0.9 m.	Provide permeable pathway below tunnel as per Scenario 2 if upgradient rise is unacceptable.

	Whilst less likely than in the fully blocking scenario, if groundwater reaches the surface, waterlogging and groundwater breakout may occur. Dropping of downgradient groundwater levels less likely as total flow across the obstruction will ultimately remain unchanged unless there is a large amount of surface discharge.	
Scenario 4: Tunnel blocks discrete drainage feature		
Initial Conditions	**Potential Post-construction Issue**	**Potential Mitigation**
		
Presence of a discrete drainage feature which is performing a significant drainage function such as a fissure or man-made culvert. Proposed tunnel could intercept and block this feature. Fissures and a culvert are known to be present at Zone 1 and could be intercepted depending on the vertical alignment of the tunnel. No indication of such features at Zone 2 although their presence cannot be ruled out.	Depending on the importance of the feature being blocked on conveying surface water or groundwater flows, water could back up behind the tunnel and break out at surface or cause waterlogging. Water levels would continue to rise until they found a new route capable of conveying the flows. This could be a surface overspill or a higher-level, below-ground fissure which had not been blocked. Dropping of downgradient groundwater levels less likely as total flow across the obstruction will ultimately remain unchanged.	As per Scenarios 2 and 3.

Scenario 5: Permeable pathway along tunnel diverts groundwater flows		
Initial Conditions	**Potential Post-construction Issue**	**Potential Mitigation**
		
As per Scenarios 2 and 3 (and possibly, but less likely, 4). Permeable pathway along tunnel alignment could occur at Zone 1 or 2 as a result of inadequate grouting of the annulus between tunnel and ground or through employment of the mitigation measures described in previous scenarios.	A permeable pathway resulting from tunnel construction and along its alignment could divert groundwater and lead to downgradient falls in groundwater level in some areas and rises in others.	Ensure that annulus between tunnel and ground is adequately grouted and, where permeable pathway mitigation (as described in previous scenarios) has been employed, ensure that this alternates with grouted, impermeable zones to prevent a continuous pathway along the tunnel length.