Amendments/Additional Information

- [ ] Amended layout of buildings/outside areas
- [ ] Additional background information
- [ ] Amended design
- [ ] Revised access arrangements
- [ ] Change of description of proposed development
- [ ] Change in site boundaries
- [x] Other (as specified below)

Further information under Regulation 22 of the Town and Country planning (Environmental Impact Assessment) Regulations 2011

20171050S
RS

Dawn Paton

From:	Rob Smith
Sent:	05 October 2017 10:40
To:	Planning
Subject:	FW: Section 22 clarification response [NLP-DMS.FID262297]
Attachments:	50303.04 Clarification letter 03.10.17.pdf; 40-RHD-WS-83-WM-RP-001 - S73 Habitats Regulations Assessment Report Rev 0.pdf

From: Amy Farrelly
Sent: 03 October 2017 16:51
To: Rob Smith
Cc: William Woods; 'Robert Staniland'; Hugh Scanlon; Aisling Kelly
Subject: Section 22 clarification response [NLP-DMS.FID262297]

Hi Rob

Please find attached our response to your clarification letter dated the 2nd October, along with a copy of the 'Shadow' Habitats Regulations Assessment Report, Hydrogeological Risk Assessment of the Cumulative Long Term Conditions and Quantitative Modelling including Groundwater Modelling to evaluate the long-term impact of the Woodsmith Mine development to meet Section 73 Application requirements, a 2017 Groundwater Model Update and a Groundwater Model: Section 73 Sensitivity and Uncertainty Analyses.

As you'll note in the letter, the photomontages will follow early next week once these are complete but all other queries are addressed.

I trust this will cover everything you need, but please let me know if you require any further information.

Kind regards, Amy

Amy Farrelly
Senior Planner and Economics Consultant
Lichfields, The St Nicholas Building, St Nicholas Street, Newcastle upon Tyne NE1 1RF

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LICHFIELDS

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Rob Smith
North York Moors National Park Authority
The Old Vicarage
Bondgate
Helmsley
York
YO62 5BP

Date: 3 October 2017
Our ref: 50303/04/HS/AFa/14881928v1
Your ref: NYM/2017/0505/MEIA

Dear Rob

Request for further information under Regulation 22 of the Town and Country Planning (Environmental Impact Assessment) Regulations 2011

Please find below our responses to the clarification request received from the North York Moors National Park Authority (NYMNPA) on the 2nd October 2017.

1 ***ES technical assessments and appendices, para. 6.28, Table 6.2*** **– this Table indicates that the area of conifer plantation to be removed would be only marginally less than in the approved scheme. This is queried taking into account that the proposed amendments would enable the majority of Whinny Wood Plantation to be retained.**

Response: The quantity of approved scheme conifer woodland to be removed shown in Table 6.2 (11.3ha) was taken from the 2014 ES and did not include the additional 2.86ha of conifer woodland to be removed in the Bund H area as identified in the 2015 SEI. Approved scheme conifer woodland to be removed should therefore be amended to 11.3 + 2.86 = 14.16ha.

The S73 scheme would result in the removal of 11.1ha of woodland and would therefore result in the retention of 3.06ha (14.16 – 11.1) of existing conifer woodland compared to the approved scheme, including 0.84ha of plantation to be retained south of Bund C near the site entrance and 2.22 ha of Whinny Wood to be retained through the relocation of the ponds.

2 ***ES technical assessments and appendices, para. 8.21, Table 8.3*** **– the updated assessment of operational stage impacts from discharge of treated sewage effluent is shown in the table as decreasing from minor adverse (approved scheme) to negligible (Section 73 proposals). Please could you clarify the basis for this revision in the context of the Section 73 proposals, which do not appear to give rise to any proposed changes to arrangements for discharge of sewage effluent.**

Response: There have been no changes to the proposals for discharge of treated sewage effluent from the approved scheme that was assessed in the SEI.

The SEI states that: "*the treated effluent would now be transported via the MTS to the Wilton MHF for disposal. This means that there would no longer be a mechanism for adverse impacts on ammonia and suspended solid concentrations and BOD in Sneaton Thorpe Beck and that the water quality impacts originally identified in the ES would no longer occur (i.e. no impact would arise).*"

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This explains that the impact moved from "minor adverse" in the September 2014 Environmental Statement to "no impact" at SEI stage in February 2015, reflecting the change to discharge treated effluent via the MTS to Wilton, rather than to Sneatonthorpe Beck. Table 8.3 incorrectly states that the impact from the approved scheme is "negligible". The correct entry should be "no impact" reflecting the SEI rather than the September 2014 ES. The impact has not changed in the S73 submission.

As requested, information to demonstrate, in quantitative terms, the predicted long term impacts of the proposed construction changes and revised operational mine site configuration on the hydrogeology of the Woodsmith Mine site and adjacent areas is enclosed with this document. This includes a 'Shadow' Habitats Regulations Assessment Report, Hydrogeological Risk Assessment of the Cumulative Long Term Conditions and Quantitative Modelling including Groundwater Modelling to evaluate the long-term impact of the Woodsmith Mine development to meet Section 73 Application requirements, a 2017 Groundwater Model Update and a Groundwater Model: Section 73 Sensitivity and Uncertainty Analyses.

In addition, updated photomontages demonstrating the construction impacts (both diaphragm walling and winding tower stages) and operational impacts, for photomontage locations 04 (*grounds of Whitby Abbey*) and 10 (*access land at Normanby Hill Top near Coast to Coast walk*), as defined in the Environmental Impact Assessment dated September 2014 are also currently being prepared and will be provided to the NYMNPA at the earliest possible opportunity.

I trust the above and enclosed information provides sufficient information to satisfy your request, but please do not hesitate to contact me if you require any further information.

Yours sincerely

Hugh Scanlon
Senior Director

Copy Rob Smith, NYMNPA; Will Woods, Sirius Minerals Plc; Robert Staniland, Sirius Minerals Plc; Simon Carter, Sirius Minerals Plc

REPORT

Sirius Minerals North Yorkshire Polyhalite Project: Section 73

'Shadow' Habitats Regulations Assessment Report.

Client: Sirius Minerals PLC

Reference: 40-RHD-WS-83-WM-RP-0001 REV 0

Revision: 00/Final

Date: 27 September 2017

Royal HaskoningDHV
Enhancing Society Together

Royal HaskoningDHV

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Document title:	Sirius Minerals North Yorkshire Polyhalite Project: Section 73
Document short title:	'SHADOW' HABITATS REGULATIONS ASSESSMENT REPORT
Reference:	40-RHD-WS-83-WM-RP-0001 REV 0
Revision:	00/Final
Date:	27 September 2017
Project number:	PB1110
Author(s):	Claire Smith
Drafted by:	Claire Smith
Checked by:	Matthew Hunt
Date / initials:	27/09/2017 MH
Approved by:	Matthew Hunt
Date / initials:	27/09/2017 MH

Classification
Project related

Royal HaskoningDHV

Table of Contents

Appendices

1 Introduction

1.1.1 In 2015 Sirius Minerals plc (Sirius Minerals) was granted planning permission (NYM/2014/0676/MEIA) to develop a polyhalite mine and underground Mineral Transport System (MTS), subject to conditions.

1.1.2 A Habitats Regulations Assessment (HRA) for the project was prepared alongside the Environmental Statement (ES) that accompanied the planning application (Royal HaskoningDHV, 2014). It considered all elements of the North Yorkshire Polyhalite Project, i.e. Woodsmith Mine, MTS and intermediate sites, Material Handling Facility (MHF) and Harbour facility. It concluded the following:

- The Harbour facility and MHF would not affect the structure or function of the Teesmouth and Cleveland Coast Special Protection Area (SPA) and Ramsar site; and
- The Woodsmith Mine or MTS sites would not affect the structure or function of the North York Moors Special Area of Conservation (SAC) or SPA as mitigation measures (including groundwater control measures) to limit any potential effect would be implemented.

1.1.3 In December 2016, a non-material amendment to the approved scheme was granted by the North York Moors National Park Authority (NYMNPA) under Section 96A of the Town and Country Planning Act 1990. The approved amendments were:

- Realignment of the main internal access road linking the approved welfare building complex and the mine site; and
- Minor amendments to the drill pad levels.

1.1.4 In addition to the above applications, information has been submitted to partially discharge conditions attached to the planning permission NYM/2014/0676/MEIA and enable the initial stages of construction. Works commenced at the site on 1 April 2017.

1.1.5 Further minor material amendments to the scheme, limited to Works at Woodsmith Mine (formerly Dove's Nest Farm), are currently being sought via an application submitted under Section 73 of the Town and Country Planning Act 1990 (the S73 application, see **Section 2**). That application was accompanied by a Supplementary Environmental Statement (SES) (Lichfields, 2017) which considers any potentially altered environmental effects.

1.1.6 Due to the nature of the S73 amendments, it has been agreed with the NYMNPA that an updated review of any effects on European Designated sites (e.g. SAC, SPA) or Ramsar sites should also support the S73 application.

1.1.7 This document presents the findings of a revised shadow HRA, incorporating a screening assessment for likely significant effect (LSE), and subsequently consideration of whether adverse effects on the integrity (structure or function) of the sites in question will be avoided. This document only focuses on those sites that are relevant to the Woodsmith Mine site. The conclusions presented in the 2014 report remain valid for the other elements of the project and have not been repeated.

1.1.8 Throughout this document, reference is made to documentation submitted by Sirius Minerals to the NYMNPA in partial satisfaction of the requirements of planning conditions, as they relate to a defined scope of works being carried out within a particular 'Phase' of development. The latest Phase to be approved by the NYMNPA was Phase 4. The S73 application covers works beyond Phase 4 through to the completion of the development. Prior to the commencement of future Phases of development, all relevant planning condition discharge documentation will be updated and submitted for approval, to ensure that the project's environmental management and monitoring and control measures remain appropriate.

2 Site Description and S73 Scheme Amendments

2.1.1 Woodsmith Mine is located approximately 4km south of the outskirts of Whitby and wholly within the boundary of the North York Moors National Park. It is fully described in the previous application documents, and that information is not repeated here.

2.1.2 The approved development site boundary is shown on approved drawing YP-P2-CX-550. The requested S73 amendments are shown on drawing 653-AP-0005.

2.1.3 In summary, the proposed S73 amendments to the approved scheme comprise:

- Woodsmith Mine site layout - Variations to the layout of buildings at the Woodsmith Mine site to include wider diameters for the Men & Materials and Minerals foreshafts. This variation replaces the need for the previously approved Drift mine access route, its associated on-site structures and the -45m level road network, as well as reducing the size requirement of the Intake Ventilation Equipment building;
- Construction methods and sub-surface structures - Amendments to the construction methods associated with the above including the removal of two of the three 45m high temporary winding towers and revised groundwater management;
- Shaft Diameters and Bunding – Adjustments to the shaft diameters and amendments to the non-screening bunding to the south of the main platform to accommodate the revised road layout and adjusted spoil quantities;
- Water Attenuation – the relocation of the water attenuation ponds into the northern field, along with the addition of a silt trap within the southern field;
- Construction and Operational Platform Extension - an extension to the southern extent of the platform with a reduction in its width and the creation of access ramps; and
- Internal Access Road – amendments to the route of the access road linking the approved welfare building to the construction/operational platform location, and the associated relocation of the gatehouse.

3 Designated Site Screening Methodology

3.1.1 The previous HRA report (Royal HaskoningDHV, 2014) initially applied a 5km buffer to each element of the project to identify sites that have the potential to be affected.

3.1.2 This buffer remains applicable to the S73 application, and has been applied around the Woodsmith Mine site boundary. The North York Moors SAC and SPA sites remain the only sites1 identified. Information relating to the sites' designations (features and objectives) are summarised in Table 1.

Table 1 – Summary of the North York Moors SAC and SPA designated features

Site Name	Summary of reasons for site designation
North York Moors SAC	The North York Moors SAC covers an area of 44,082ha with a general character of heath and scrub, inland water bodies, bogs and marshes, dry grassland, humid grassland and woodland. It qualifies as a SAC for the following features: • Northern Atlantic wet heaths with *Erica tetralix*, for which this is one of the best areas in the United Kingdom. • European dry heaths, for which this is one of the best areas in the United Kingdom. • Blanket bogs, for which the area is considered to support a significant presence. Natural England has developed conservation objectives for the SAC which aim to avoid the deterioration of the qualifying habitats and the habitats of qualifying species, and significant disturbance of those qualifying species, ensuring that the integrity of the site is maintained and the site makes a full contribution to achieving Favourable Conservation Status of each of the qualifying features.
North York Moors SPA	The North York Moors SPA covers an area of 44,082ha and qualifies under Article 4.1 of the Birds Directive by supporting populations of European importance of the following Annex 1 species: • Golden plover *Pluvialis apricaria*. 526 pairs representing at least 2.3% of the breeding population in Great Britain (at the time of designation in 2001). • Merlin *Falco columbarius*. 40 pairs representing at least 3.1% of the breeding population in Great Britain (at the time of designation in 2001). The conservation objectives of the SPA aim to avoid the deterioration of the habitats of the qualifying features, and significant disturbance of the qualifying features, ensuring that the integrity of the site is maintained and the site makes a full contribution to achieving the aims of the Birds Directive.

4 Assessment of Potential for LSE

4.1.1 The previous HRA report (Royal HaskoningDHV, 2014) assessed each element of the consented project to determine likelihood of significant effect (LSE) with respect to each relevant qualifying feature for the sites identified. This was undertaken in line with the Planning Inspectorate's Guidance Note 10 (The Planning Inspectorate, 2013) and agreed with Natural England. The same approach has been followed here.

4.1.2 Within the screening stage of this shadow HRA, where LSE cannot be ruled out beyond reasonable scientific doubt, the precautionary principle has been applied and potential for LSE concluded. This ensures that any potential implications for the site(s) are assessed further as part of the Appropriate Assessment (AA) stage (**Section 5** of this report).

4.1.3 The previous HRA report was also informed by the findings of several baseline ecological surveys (i.e. botanical, breeding bird and wintering bird surveys) for the Woodsmith Mine site. These surveys (summarised in **Table A1, Appendix A**) were undertaken from October 2011 to October 2012 and during the period February 2013 to January 2014. They were supplemented by a detailed ecological desk-based study and information obtained from stakeholders.

4.1.4 Further surveys for snipe, curlew and nightjar were undertaken in 2016 of areas within and around the Woodsmith Mine site. Although these species are not qualifying features for the North York Moors SAC or SPA, these surveys also provided supplementary information on the underlying habitats and their quality. Full details of these surveys are reported within Phase 2 condition discharge reports (40-RHD-WS-83-EN-SV-0001 and 40-RHD-WS-83-EN-SV-0003).

4.1.5 In addition to ecological surveys, Sirius Minerals has implemented a programme of ground and surface water monitoring, in accordance with the requirements of the planning permission. This is providing weekly and monthly data (as appropriate), within the area of influence of the works, on:

- Groundwater level and quality;
- Spring flows and spring water quality; and
- Surface water flows, quality and geomorphology (at Sneaton Thorpe Beck).

4.1.6 Potentially significant effects that could influence the North York Moors SAC and SPA because of the S73 amendments are identified in **Table 2**.

Table 2 Potentially significant effects associated with the S73 amendments that could affect the North York Moors SAC and SPA

Designated site	Potential effects	Presented in screening matrix (Table 3) as
North York Moors SAC	Direct effect of dust generated during construction activities (e.g. earthworks, use of the haul roads) settling onto the SAC habitats (although prevailing wind is from the south-west).	Dust
	Indirect effects associated with the emissions on and around the Woodsmith Mine site (including from plant and on-site power equipment) and deposition of nitrogen on the SAC habitats.	Nitrogen deposition – onsite plant and power generation
	Indirect effects associated with emissions from road vehicles and deposition on the SAC habitats.	Nitrogen deposition – road traffic movements
	Alteration to groundwater flows affecting water dependent habitats and species within the SAC.	Alteration to groundwater
	Alteration to surface water flows affecting water dependent habitats and species within the SAC.	Alteration to surface water
North York Moors SPA	Indirect effect of dust generated during construction activities (e.g. earthworks, use of the haul roads) settling onto supporting habitats which the SPA birds could use.	Dust
	Indirect effects associated with emissions on and around the Woodsmith Mine site (including from plant and on-site power equipment) and deposition of nitrogen on supporting habitats which the SPA birds could use.	Nitrogen deposition – onsite plant and power generation

Designated site	Potential effects	Presented in screening matrix (Table 3) as
	Indirect effects associated with emissions from road vehicles and deposition on supporting habitats which the SPA birds could use.	Nitrogen deposition – road traffic movements
	Alteration to groundwater flows affecting water dependent supporting habitats within the SPA.	Alteration to groundwater
	Alteration to surface water flows affecting water dependent supporting habitats within the SPA.	Alteration to surface water
	Disturbance to birds (merlin and golden plover) from noise and/or visual disturbance.	Disturbance

4.1.7 These identified effects are considered in more detail in a screening matrix (**Table 3**), which sets out relevant considerations and conclusions as to whether there is a LSE on the designated sites.

Table 3 Potential effects of the S73 amendments.

Description of potential effects of the S73 amendments on the North York Moors SAC (*qualifying features are Northern Atlantic wet heaths with Erica tetralix; European dry heaths; and Blanket bogs*) and the North York Moors SPA (*qualifying features are golden plover and merlin*)	LSE on SAC	LSE on SPA
Dust During the construction phase, potential impacts associated with airborne emissions in the form of dust will be generated from earthworks and vehicles using the haul roads. A number of dust control measures (e.g. programming of earthworks to avoid dry and/or windy conditions) are proposed and these are set out in the Construction Environmental Management Plan (eg 40-RHD-WS-70-EN-NT-002 for Phase 4 construction works, and similar measures will apply to all construction phases). Existing vegetation within the boundaries of Woodsmith Mine, as well as the band of naturally established woodland along the edge of Ugglebarnby Moor, will capture airborne dust. Any deposited material onto this established woodland will then be removed by precipitation and, in combination with the distance of these habitats from the Woodsmith Mine site boundary and the prevailing (south westerly) wind direction, the potential for the deposition of dust onto the qualifying SAC habitats will be low. The S73 amendments do not result in any material changes to the impacts previously identified in respect of the consented scheme, and a LSE can therefore be excluded. Therefore, the conclusion remains the same as that made in the 2014 HRA report.	No	No
Nitrogen deposition – onsite plant and power generation Indirect effects arising from vehicle and plant emissions and the deposition of nitrogen on areas of heathland and blanket bogs of the North York Moors could be experienced. Nitrogen deposition rates were considered as part of the 2014 HRA assessment. The S73 amendments will not result in any change to the scenarios considered as part of that assessment. Considering this, in combination with measures to control emissions as outlined in the Construction Environmental Management Plan (eg 40-RHD-WS-70-EN-NT-0002) and the Construction Vehicle and Plant Management Plan (eg 40-RHD-WS-70-CI-PL-0005), and information outlined in the Generators Emissions Assessment (eg 40-RHD-WS-70-EN-RP-0002), potential effects will be controlled. Consequently, LSE can be excluded. Therefore, the conclusion remains the same as that made in the 2014 HRA report.	No	No

Description of potential effects of the S73 amendments on the North York Moors SAC (*qualifying features are Northern Atlantic wet heaths with Erica tetralix; European dry heaths; and Blanket bogs*) and the North York Moors SPA (*qualifying features are golden plover and merlin*)	LSE on SAC	LSE on SPA
Nitrogen deposition – road traffic movements Emissions will be associated with road traffic movements which could result in changes in nitrogen deposition rates. A number of road transport mitigation measures are secured through relevant planning conditions and are documented in the Phase 4 Construction Traffic Management Plan (eg 40-RHD-WS-70-CI-PL-004) and the Construction Environmental Management Plan (eg 40-RHD-WS-70-EN-NT-0002) submitted in phased discharge of planning conditions applied to the consented scheme. These measures will reduce the impact of emissions from road traffic, and will be applied to the S73 scheme if approved. The S73 amendments do not result in any material changes to the impacts previously identified in respect of the consented scheme, and a LSE can therefore be excluded. Therefore, the conclusion remains the same as that made in the 2014 HRA report.	No	No
Groundwater Groundwater and groundwater fed features (e.g. spring flushes) could be affected during construction (through dewatering requirements) and the operation of the consented development, potentially impacting the SAC habitats. A vegetation and mapping survey of Ugglebarnby Moor (PCA, 2014), and associated hydrogeological risk assessment modelling, identified that of all the communities recorded, only those found in the Spring Flush area of the Southern Dry Heath are potentially groundwater dependent. It concluded that the recorded communities are likely to be more a result of topographical features and soil conditions than groundwater conditions (PCA, 2014). However, the potential for changes to the groundwater resource or flow regime to affect these habitats (which are not supporting habitats to the SPA species), whilst low, is present. The S73 amendments do not result in any changes to the potential impacts identified in either the consented scheme or the SES. However, the modelling to date has shown minor changes in the range of seasonal groundwater level fluctuations. As such the potential impact on groundwater flows (and in turn a LSE) cannot be ruled out at this stage.	Yes	N/A
Surface water The consented scheme includes a surface water drainage strategy to mitigate impacts on surface water at the Woodsmith Mine site. The S73 amendments do not result in any changes to the potential impacts identified in either the consented scheme or the SES. Therefore, there will be no effect on the surface water regime as drainage control measures (e.g. surface water retention ponds)	No	N/A

Description of potential effects of the S73 amendments on the North York Moors SAC (*qualifying features are Northern Atlantic wet heaths with Erica tetralix; European dry heaths; and Blanket bogs*) and the North York Moors SPA (*qualifying features are golden plover and merlin*)	LSE on SAC	LSE on SPA
incorporated in the scheme remain unchanged from the currently consented development. This conclusion remains the same as that made in the 2014 HRA report.		
Disturbance No evidence of golden plover or merlin has been recorded to date within the Woodsmith Mine site or within the designated habitat that is adjacent to the mine site (up to approximately 1km from the site boundaries). Although no golden plover or merlin have been recorded during breeding bird surveys undertaken to date, consultation with Natural England prior to the 2014 application indicated that both golden plover and merlin have been recorded in these areas previously (although were not recorded during 2012, 2013 or 2014). There remains the potential that they could return to the area. Habitats within the Woodsmith Mine site have been assessed as poor breeding bird habitat and only support a typical range of common bird species; key species are skylark and meadow pipit (PCA, 2014). With respect to lighting, a strategy has been prepared in accordance with RSPB guidance to minimise potential impacts on bird species using both the Woodsmith Mine site and its immediate surroundings. Habitats within the adjacent areas of the SPA (up to 1km from the site boundary) have been assessed as providing poor breeding and foraging habitat for golden plover and merlin (PCA, 2014). It is considered that the habitat within the SPA is unsuitable for these species due to the general age of the established scrub and woodland. Habitats within the wider area do have the potential to support merlin and golden plover. Modelling has shown that noise levels will not exceed the thresholds previously considered for the consented scheme (Lichfields, 2017). These remain below the disturbance thresholds (72dB) for both merlin and golden plover. As such, and together with implementation of measures outlined in the Noise and Vibration Monitoring Plans (NVMP), a LSE will not arise.	N/A	No

5 Appropriate Assessment

5.1.1 The S73 amendments at Woodsmith Mine will not directly affect habitats or species within the boundary of the North York Moors SAC and SPA as all the works are outside the boundaries of this designated site.

5.1.2 The 2014 HRA report concluded no LSE on the North York Moors SPA. This remains the conclusion for the S73 amendments, as shown in **Table 3**.

5.1.3 The S73 amendments at Woodsmith Mine will not result in a LSE on most of the SAC features, with the exception of potential effects on some potentially groundwater-dependent species found in the 'Spring Flush' area of Ugglebarnby Moor, within the North York Moors SAC.

5.1.4 **Appendix B** to this Shadow HRA report presents a Hydrogeological Risk Assessment of the cumulative, long-term impacts of the Woodsmith Mine development on groundwater levels and spring flows (FWS, 2017). The Hydrogeological Risk Assessment has been informed by the results of quantitative, multi-layered Transient and Dynamic State modelling, undertaken by ESI Limited.

5.1.5 Groundwater management measures incorporated within the design of the permanent mine site development and taken to be 'embedded mitigation' within the modelling, are as follows:

- Within the Shaft Platform and Laydown areas, a natural geological clay barrier or a re-compacted clay liner will be constructed over the Moor Grit aquifer;
- A trench constructed to promote re-infiltration of surface runoff to recharge the Moor Grit Formation up hydraulic gradient of the source area to Moorside Farm Spring; and
- Groundwater drainage areas, beneath Bunds E and F, will collect spring water issues from the Scarborough and Cloughton Formations, for discharge to the attenuation ponds within the main surface water drainage system.

5.1.6 Further detail of these mitigating features is provided in the S73 submission and within **Appendix B**.

5.1.7 As a result of the changes to the shaft platform level being raised above groundwater levels in the Moor Grit aquifer (see **Paragraph 1.1.3**), there is no longer a groundwater management requirement to incorporate the grout curtain and pressure relief drain (within the previously approved scheme) within the S73 submission. As such, these features have been excluded from the quantitative modelling.

5.1.8 The Hydrogeological Risk Assessment concludes that "*the cumulative and long term effects of the development will cause a very low physical change in the groundwater levels in the Moor Grit or Scarborough Formations underlying the hydrogeologically supported Spring Flush ecosystem and a low physical change in the groundwater levels and spring flow rates at the Moorside and Soulsgrave Farm spring water supplies. This very low change in groundwater levels is typically at times of the year when groundwater levels are low and where flow from the Spring Flush has been observed to be intermittent and dominated by contribution of recharge to the Moorside Farm Spring via superficial deposits which would not be affected by minesite development*".

5.1.9 Furthermore, the modelling has also confirmed that there is no requirement for any additional groundwater control measures, including the grout curtain and pressure relief drain.

5.1.10 On the basis of the above, and the detailed information presented in **Appendix B**, it can be concluded that there will be no adverse effect on the integrity of the North York Moors SAC as a result of the proposed changes to the Woodsmith Mine development.

6 References

FWS Consultants Limited (FWS) (2017) Hydrogeological Risk Assessment of the Cumulative Long Term Conditions.

INCA (2016a) Breeding bird survey Seaton Moor & Ugglebarnby Moor.

INCA (2016b) Nightjar survey Haxby Plantation & Ugglebarnby Moor.

Lichfields (2017) Woodsmith Mine Supplementary Environmental Statement.

Paul Chester and Associates (2014) York Potash Project Proposed Mine Baseline Ecology Surveys.

Planning Inspectorate (2013). Habitats Regulations Assessment for Nationally Significant Infrastructure Projects. August 2013, Version 5.

Royal HaskoningDHV (2014) York Potash Project Environmental Statement: Part 2, Appendix 11.3 Habitats Regulations Assessment.

Appendix A

Table A1 – Summary of selected ecological baseline surveys undertaken for the Woodsmith Mine site.

Ecological survey	Reference	Description
Phase 1 Habitat Survey (2012)	Proposed Mine baseline ecology surveys report (PCA, 2014)	These surveys followed Joint Nature Conservation Committee (JNCC, 2010) guidance which was extended to include a search for evidence of the presence of, or potential to support, notable and protected species in or adjacent to the Site, as recommended by CIEEM.
NVC survey (2012 and 2013)		A botanical walkover survey of the Site was undertaken and broadly followed the standard methodology for Phase 2 vegetation surveys (National Vegetation Classification, Rodwell, 2000).
Breeding bird surveys (2012, 2013 and 2014)		Breeding bird surveys of the site undertaken in accordance with the Common Bird Census (CBC) methodology, described in Marchant (1983).
Wintering bird survey (2011/12 and 2013/14)		Golden plover and other moorland waders survey followed the Brown and Shepherd (1993) methodology for censusing upland waders.

Appendix B

PROJECT NUMBER	1433Dev
PROJECT TITLE	NORTH YORKSHIRE POLYHALITE PROJECT
CLIENT	Sirius Minerals Plc 7-10 Manor Court Manor Garth SCARBOROUGH YO11 3TU
REPORT TITLE	Hydrogeological Risk Assessment of the Cumulative Long Term Conditions at Woodsmith Mine, North Yorkshire
REPORT REFERENCE	1433DevOR296
DOCUMENT NUMBER	40-FWS-WS-83-PA-RA-0002

REVISION	**Date**	**Checked**
Final	27/09/2017	RIL

FWS Geological & Geo-Environmental Consultants

SIRIUS MINERALS PLC – THE NORTH YORKSHIRE POLYHALITE PROJECT

REPORT	HYDROGEOLOGICAL RISK ASSESSMENT OF THE CUMULATIVE LONG TERM CONDITIONS
SITE	WOODSMITH MINE, NORTH YORKSHIRE
DOCUMENT NUMBER	40-FWS-WS-83-PA-RA-0002

1433DevOR296Rev5/September 2017

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CONTENTS

HYDROGEOLOGICAL RISK ASSESSMENT OF THE CUMULATIVE LONG TERM CONDITIONS AT WOODSMITH MINE, NORTH YORKSHIRE

1 INTRODUCTION

1.1 General Background

Since approval, detailed in planning permission NYM/2014/0676/MEIA for Woodsmith Mine, modifications have been undertaken to the application documentation to address design amendments. These modifications have included amendment and revision to the foreshafts, substructures, drift portal, tunnel and to the earthworks aspects of the mine surface development.

As part of the Section 73 submission, which detailed these modifications, a hydrogeological risk assessment was compiled by FWS Consultants Ltd on behalf of Sirius Minerals (Ref 1). Subsequent to issue of that report, a meeting was held with the North York Moors National Park Authority and Natural England on 5th July 2017 to discuss the results of quantitative modelling from previous construction phases and the implications to long term groundwater conditions, post-construction. At that meeting it was agreed that, now the broader scheme has been established for the surface mine development, all future hydrogeological risk assessment and modelling would consider and incorporate the cumulative and long term impacts of the final scheme development.

This document has therefore been prepared to provide an assessment of the results of quantitative modelling by ESI (Ref. 2) of the predicted changes to groundwater levels and spring flow rates caused by the cumulative and long term impacts of the finished mine site development.

1.2 Objectives

The purpose of this document is to:-

- Provide details of the hydrogeology of the site and adjacent areas.
- Provide details of the finished mine site development.
- Provide an assessment of the quantitative multi-layered hydrogeological modelling conducted to analyse the potential magnitude of the impacts of the finished landform on groundwater levels and spring flows.
- Identify, where appropriate, any additional hydrogeological mitigation measures that may be warranted as part of the development.

2 DATA SOURCES

The data considered within this report are from the following sources:-

Hydrogeological Data

- Hydrogeological Baseline Report for the Woodsmith Mine, North Yorkshire 2012 to 2016 (1975OR01; Ref. 3).
- Hydrogeological Risk Assessment For the Section 73 Works At Woodsmith Mine, North Yorkshire (1433DevOR226 Rev2 July 2017 Ref. 1).
- ESI Ltd, 2017 - York Potash: Groundwater Modelling to evaluate the cumulative and long – term impact of the operational development corresponding to the Section 73 Application, Report No. 61415R9 D2 (Ref. 2; included as Appendix 2).

Development Details Presented in the Section 73 Application

The following Section 73 construction development details have been considered within this hydrogeological risk assessment, as provided by Sirius Minerals, Arup and Cartwright Pickard.

3 DETAILS OF THE LONG TERM OPERATIONAL MINESITE LANDFORM

3.1 General Description

This report presents a hydrogeological risk assessment of the long term condition of the completed mine site development for the maximum size of the landscaped bunds included in the Section 73 submission, as shown on Arup Drawing 40-ARI-WS-71-CI-DR-1036, 40-SMP-WS-10-PA-DT-0001 and YP-P2-CX-509.

The Operational Phase development comprises earthworks and substructures, penetrating the superficial deposits and bedrock, which interact with the groundwater system. A summary drawing of the key long term operational construction and earthworks elements is presented in Drawing 1433DevOD292. Presented below is a summary of the operational elements impacting on the groundwater system and the hydrogeological regime post development.

The long term earthworks and site surfacing elements interacting with the groundwater system will include the following:-

- Earthworks to create the lined ponds, areas of hardstanding including the Shaft Platform and the welfare areas will reduce infiltration into the ground surface.
- Landscaped Bunds A, B and G will be constructed of extractive material and will incorporate surface water drainage reducing infiltration into the ground surface.
- Landscaped Bunds C, D, E and F will be constructed of extractive material and will have a geocomposite drainage layer above a designed capping and lining system reducing infiltration into the ground surface.

The principal long term substructure elements interacting with the groundwater system will include the following.

- Lined shaft basement construction features at the Service Shaft and Production Shaft to around 5.5 m below ground level will locally impede groundwater flows in the Moor Grit Aquifer.

- Two diaphragm walls at the Service and Production shafts, with outside diameters of 37.8 m and 34.8 m extending to a depth of 60 m into the Ellerbeck Formation and their associated 11m diameter shafts together with the 11.05m diameter MTS shaft extending to a depth of 120m into the Whitby Mudstone. These structures will create local impedance to groundwater flows in the Ravenscar Formation aquifers.

3.2 Groundwater Management Measures

Groundwater management measures incorporated within design of the permanent mine site development, are as follows:-

- Within the Shaft Platform and Laydown areas, a natural geological clay barrier or a re-compacted clay liner are constructed over the Moor Grit aquifer.

- A re-infiltration trench, collecting runoff from the catchment area on Bund C as illustrated in Arup Drawing YP-P2-CX-509, will promote re-infiltration of surface runoff to recharge the Moor Grit Formation up hydraulic gradient of the source area to Moorside Farm Spring.

- Groundwater drainage areas, beneath Bunds E and F, will collect spring water issues from the Scarborough and Cloughton Formations, for discharge to the attenuation ponds within the main surface water drainage system.

As part of this development, now that the Shaft Platform has been raised above groundwater levels in the Moor Grit aquifer, there is no longer a groundwater management requirement to incorporate the grout wall and relief drain from the approved scheme within the Section 73 submission. As such, the modelling presented in this report has considered the Section 73 scheme, excluding the grout wall and relief drain.

3.3 Duration of Operation

For the purpose of this hydrogeological risk assessment, it has been assumed that the duration of minesite operation will be such that steady state long term average conditions will establish. Model results therefore represent cumulative long term average (LTA) effects of the mine site development and the re-infiltration trench on the groundwater system. These predicted effects are the worst case precautionary maximum expected long term average change under the imposed recharge condition.

4 MINESITE HYDROGEOLOGICAL CONDITIONS

4.1 Introduction

From the geometry and construction details of the completed mine development, presented in Section 3, and the baseline hydrogeological conditions determined for the site (Ref. 1), the following sections present an overview of the interaction between aquifer conditions, the completed development surface and the below ground structures.

Within this Section, reference is made to specific groundwater monitoring well locations, as shown in Drawing 1433DevOD292.

4.2 Geology

4.2.1 General

Presented below is a summary of the superficial deposits and strata within the Ravenscar Formation that form the sensitive aquifers impacted on by the surface mine development. Drawing 1433DevOD292 (Appendix 1) illustrates the substructures, zones of no and low recharge, and groundwater management measures on the geological plan of the minesite and the adjacent Ugglebarnby and Sneaton Low Moor areas.

4.2.2 Superficial Deposits

Within the SAC, the soils consist of topsoil and peat, while on the minesite there is a thin covering of topsoil. The superficial deposits across the minesite and the moorland areas of the SAC consist of sandy gravelly clay (Glacial Till) to depths between 1.4m to 4.7m bgl, generally thinning towards the southeast of the minesite, and containing frequent sand lenses at the base of this unit.

4.2.3 Long Nab Member

The Long Nab Member underlies the south of the minesite and Sneaton Low Moor. It comprises weathered grey or orange/yellow fine to medium grained sandstone over a thin (0.2m to 0.45m thick) layer of dark grey mudstone.

4.2.4 Moor Grit Member

The Moor Grit Member un-conformably overlies the Scarborough Formation and comprises a grey, iron-stained fine to medium grained cross bedded sandstone with occasional medium to coarse gravel to pebble beds, discontinuous argillaceous beds and thin coal laminations within the mid-section of this unit. The upper part of this sandstone unit is distinctly weathered to de-structured, whilst the lower part of the sandstone unit is only partially weathered. This sandstone unit ranged in thickness from 2.3m to 13.2m and the discontinuous argillaceous units within the mid-section ranged from 1m to 4m in thickness. The base of the Moor Grit has a maximum dip of approximately 2° to the east beneath the SAC moorland and Woodsmith Mine, forming a shallow basin-like structure.

4.2.5 Scarborough Formation

The Scarborough Formation comprises three horizontal to sub-horizontal bedded weak to very weak, partially to distinctly weathered units including an upper moderately to highly fractured mudstone or siltstone, a grey-green sandstone/siltstone mid-section unit and a basal mudstone unit. To the west of the site, in the northern part of Ugglebarnby Moor (HG106A/GW121B), the lower argillaceous unit is a light to dark grey sandy argillaceous limestone with shell fragments.

The upper mudstone/siltstone unit is on average 2m thick. The middle sandstone unit ranges in thickness from 0.3m to 5.7m and the lower mudstone ranges in thickness from 0.05 to 9m. The upper mudstone unit is discontinuous, especially towards the northern boundary of the

Woodsmith Mine. The base of the Scarborough Formation dips at a relatively shallow angle of around 1° to the east beneath the SAC and Woodsmith Mine, forming a basin-like structure.

4.2.6 Cloughton Formation

The Cloughton Formation comprises a series of interbedded sandstones and mudstones with occasional siltstones of between 23.5m to 52m thick. Beneath Ugglebarnby Moor, the Cloughton dips at a relatively shallow angle (1 to 5°) to the east, becoming roughly horizontal beneath, and to the east of, the Woodsmith Mine.

The upper part of the Cloughton Formation comprises a weak to extremely weak weathered mudstone of between 1 to 5m thick, which thickens to the south. This overlies a medium strong to strong, partially to distinctly weathered, fine to medium grained sandstone, containing interbedded mudstone and occasional coaly and carbonaceous beds, particularly towards the base. The total thickness of this sandstone-dominated Formation ranges from 11.2 to 33.1m. The Formation becomes more sandy and thicker towards the south, with fewer mudstone beds. In the central part of the minesite, the sandstone sequence contains a higher proportion of mudstone/siltstone beds. The base of the Cloughton is dominated by an interbedded mudstone/siltstone sequence, of between 20 to 25m thick.

4.2.7 Eller Beck Formation

The Eller Beck Formation comprises 4 to 7 m of fine to medium sandstone, with a basal shale and ironstone unit (Ref. 30).

4.2.8 Saltwick Formation

The Saltwick Formation was between 37 to 40 m thick and comprises a series of interbedded sandstones, mudstones and siltstones, with some thin coals, with an upper argillaceous unit, a middle arenaceous unit and then a basal argillaceous unit.

4.3 Landform and Structures Forming the Operational Development

4.3.1 Hydrogeological Development Considerations

As illustrated in Drawing 1433DevOD292 (Appendix 1) the final development of Woodsmith Mine will entail the following construction zones and substructure elements that will impact on groundwater flows and recharge within the Ravenscar aquifers:

<u>Zones of No Recharge</u>

- The tiered Shaft Platform and the Laydown areas will either have a hardstanding or landscaped surface underlain by an insitu natural or enhanced clay geological barrier overlying the Moor grit aquifer. These surfacings will restrict surface water recharge into the underlying bedrock.

- The Welfare Unit and access road will have hardstanding surfacing underlain by predominantly cohesive Glacial Till overlying the Long Nab and Moor Grit aquifers. This surfacing will restrict surface water recharge into the underlying bedrock.

- The surface water drainage ponds and attenuation basins will have a landscaped surface underlain by insitu or engineered clay overlying the Moor Grit, Scarborough or Cloughton aquifers. This surfacing will restrict surface water recharge into the underlying bedrock.
- Landscaped bunds C, D, E and F will have a capping and lining system that will restrict surface water infiltration into the underlying Moor Grit and Scarborough aquifers.

Zones of Low Recharge

- Landscaped Bunds A, B and G, and general landscaped areas across the site will have a soil cover and a surface water drainage system that will reduce but not inhibit permeation of surface water ingress into the underlying Glacial Till overlying the Long Nab, Moor Grit, Scarborough and Cloughton aquifers.

Substructure Elements

- The diaphragm walling and shaft structures to the Production, Service and MTS shafts will form permanent and low permeable structure's that locally impact on groundwater flows in the Moor Grit, Scarborough, Cloughton and Saltwick aquifers.

- The basement structure's to the Production and Service Shafts will form permanent and low permeable structure's that locally impact on groundwater flows in the Moor Grit aquifer.

Permanent Groundwater Management Measures

- The re-infiltration trench constructed around Bund C will enable surface water runoff, collected from within the capping system to soakaway into the Moor Grit strata.

- The two groundwater drainage areas beneath Bunds E and F collect local surface water issues from the Scarborough Formations.

4.3.2 Aquifer Conditions

From the results of the ground investigation and the baseline groundwater monitoring, a summary is provided in Table 1 overleaf of the aquifer units, the interpreted groundwater surface, design permeability characteristics and water quality conditions that characterise the hydrogeological conditions within the zones of no and low recharge and substructure elements associated with the final development landform.

Table 1 Aquifer and Groundwater Conditions within Principal No and Low Recharge Zones and around Substructure Elements

Development Area			Southern Working Platform	South Shaft Platform	North Shaft Platform	Welfare Facility	Bund C and Re-Infiltration Trench	Basement substructures
Development Level		m AOD	~208	203.00	203.5	202	211 to 214	203
Superficials	Current Ground Level	m AOD	204.1 to <203.5 Platform construction incorporating clay barrier	203.1 to <202.5 Shaft Platform construction incorporating clay barrier	203.5 Shaft Platform construction incorporating clay barrier	202	209 to 212	203
	Groundwater Conditions	m AOD	none	none	spring water supplies at water seepage at 202.0	None	None	None
Moor Grit	Top & Base Level of Aquifer	m AOD	203.8 to 197.38	(GCBH9) ~200.4 to 192.0	(GCBH07) ~202.0 to 193.0	~200	197 to 210	193 to 202
	Inferred Groundwater Surface (Winter, Summer & Mean levels)	m AOD	~197.98 to 206.13	Winter ~200 Summer ~198	Winter 198.6 to 203.0, average 201.7 Summer 198.3 to 202.9, Mean 200.4 (HG115 & HG116)	Winter ~200 Summer ~198	Winter ~209 Summer ~205 (GW130 &131)	Winter 197.5 to 200.6, average 198.9 (BHs 505 & 507)
	Aquifer Design Permeability	m/s	Most Likely 1.3 x10^{-5} m/s					
	Water Quality		Good					
Scarborough Formation	Top and Base Level of Upper Aquitard Unit	m AOD		~192.0-191.5	~193 to 191.5			193.0 to 192.1
	Upper Aquitard Design Permeability	m/s	Most Likely 4.0 x 10-6 m/s					
	Elevation of Mid-Section Permeable Aquifer	m AOD		~191.5 to 188.3	~191.5 to 188.0			192.1 to 189.5
	Inferred Groundwater Surface	m AOD		~195	NIA			190.9 to 193.6
	Aquifer Design Permeability	m/s	Most Likely 1.3 x 10^{-5} m/s (Fractures 5.2 x 10^{-4} m/s)					
	Water Quality		Good					
	Elevation of lower Aquitard Unit	m AOD		~18.3 to 184.5	~188.0 to 184.0			192.1 to ~185.5
	Lower Aquitard Design Permeability	m/s	Most Likely K_h 2 x 10^{-6} m/s, K_v 1 x 10^{-8} m/s					

NIA = No Information Available

5 RECEPTORS

5.1 Receptor Sensitivity

The sensitivity of groundwater receptors has been assessed in terms of their ability to accommodate physical or chemical change and on the impact any change may have on a regional or local ecological or other environmental system. By adopting this approach to the qualitative assessment, the most sensitive receptors are determined to be those with very limited or no capacity to accommodate physical and/or chemical change that are of very high importance as a groundwater resource. Conversely very low sensitivity receptors are those that can generally tolerate physical and/or chemical changes and are of low importance as a groundwater resource. Groundwater receptor characteristics and receptor examples are detailed in Table 2 below:-

Table 2 – Sensitivity Evaluation

Sensitivity	Groundwater Receptor Characteristics	Receptor Examples
Very High	• has very limited or no capacity to accommodate physical or chemical changes • supports internationally important ecological, amenity or landscape features	• licensed public water supply or major industrial abstractions (e.g. SPZ 1/2) • licensed/unlicensed abstractions and springs providing potable water supply, for which there is no alternative source (e.g. mains water) • designated SAC, SPA, or Ramsar site with fauna or flora that are hydrogeologically supported from groundwaters within rock aquifers • surface water bodies supporting the above
High	• has limited capacity to accommodate physical or chemical changes • supports nationally important ecological amenity or landscape features	• designated 'Principal Aquifer' • licensed/unlicensed abstractions and springs providing potable water supply, for which an alternative source (e.g. mains water) is available • SSSI, NNR with fauna or flora that are hydrogeologically supported from groundwaters within rock aquifers • designated SAC, SPA, or Ramsar site with fauna or flora that are supported from both surface runoff and groundwaters within superficial or rock aquifers • surface water bodies supporting the above
Medium	• has limited capacity to accommodate physical or chemical changes • supports regionally important ecological, amenity or landscape features	• designated 'Secondary A (or Undifferentiated) Aquifer' • regionally important wildlife sites with fauna or flora that are hydrogeologically supported from groundwaters within rock aquifers • non-potable licensed abstractions • surface water bodies supporting the above or classified as Good under Water Framework Directive
Low	• has moderate capacity to accommodate physical or chemical changes • supports locally important ecological, amenity or landscape features	• non-potable unlicensed abstractions • local wildlife sites (LNR, SNCI, RIGS), country parks with flora hydrogeologically supported from groundwaters within rock aquifers • designated SAC, SPA, or Ramsar site with fauna or flora that are not hydrogeologically supported from groundwaters within rock aquifers • surface water bodies supporting the above or classified as Moderate under Water Framework Directive

Sensitivity	Groundwater Receptor Characteristics	Receptor Examples
Very Low	• generally tolerant of and can accommodate physical or chemical changes • supports no features of significant ecological, amenity or landscape value	• designated 'Secondary B Aquifer' or 'Unproductive Strata' • surface waters with no important, dependent receptors • SSSI, NNR with fauna or flora that are not hydrogeologically supported from groundwaters within rock aquifers

All groundwater level, spring flow and water quality data referred to in this report is presented in detail in the revised Hydrogeological Baseline Report (Ref. 1) from which five types of groundwater receptors have been identified in the vicinity of the Woodsmith Mine that could be impacted on by its long term operational condition. These are streams, springs, private water supplies, the Special Areas of Conservation containing potentially groundwater-supported terrestrial ecosystems, and controlled waters in sensitive aquifers comprising the Secondary A Aquifers, as summarised in Table 3 below.

Table 3 – Receptor Sensitivity

Type	Receptor	Sensitivity
Sensitive Aquifers	Moor Grit Member	Medium
	Scarborough Formation	Medium
	Cloughton Formation	Medium
	Saltwick Formation	Medium
Base Flow Springs	Doves Nest Farm Spring (DNS1)	Very Low
	Ugglebarnby Moor Spring (SP01)	Very Low
	Springs Northwest of Ugglebarnby Moor (SP02, SP03)	Very Low
	Springs North of Woodsmith Mine (SP04)	Very Low
	Springs North of Woodsmith Mine (KHF)	Very Low
Spring Water Supplies	Moorside Farm Spring (MF2)	High
	Soulsgrave Farm Spring (SF2)	High
	Newton House Farm Spring (NHF1)	High
Groundwater Abstractions	Sneaton Low Moor Caravan Park	High
Ecological Receptors	Ugglebarnby Moor Northern Dry Heath Area	Low
	Ugglebarnby Moor Central Wet Heath Area	Low
	Ugglebarnby Moor Southern Dry Heath Area	Low
	Ugglebarnby Moor Southern Spring Flush	High
	Sneaton Low Moor Dry Heath Area	Low
Surface Waters	Sneaton Thorpe Beck	Low
	Little Beck	Medium

From the previous hydrogeological risk assessments (Ref 1, 4, 5, 6, and 7), the principal sensitive hydrogeological receptors identified in close proximity to the operational mine will include; the two springs used for domestic water supplies at Moorside and Soulsgrave farms and the Spring Flush ecosystem.

As the springs provide unlicensed potable water supplies, for which an alternative source (e.g. mains water) is available, they are considered as of "High" sensitivity.

With regards to the Spring Flush area, in the original hydrogeological risk assessment submitted in support of the Planning Application (Ref 1), this was categorised in 2014 as of "Very High" sensitivity" on the basis that it was a hydrogeologically supported terrestrial ecosystem within an

SAC designated area. Subsequent baseline and construction phase monitoring between 2014 and 2017 has demonstrated that this ecosystem is however, sustained by a combination of surface water runoff, and seasonal and intermittent spring flows that are sourced from both superficial glacial soils and the Moor Grit aquifer. This is demonstrated in the Hydrogeological Baseline Report that shows that rainfall recharge is the predominant process with the Moor Grit aquifer providing a secondary ephemeral source of recharge. This is supported by the ecological survey undertaken by Paul Chester Associates (Ref. 4) that the plant life is maintained by topography and surface water from rainfall.

As such, in view that this terrestrial ecosystem is partially supported by surface runoff and only intermittently sustained by spring groundwater flows from the rock aquifer, it is categorised as of "High" sensitivity in terms of its sensitivity to hydrogeological conditions.

In addition to these receptors of "High" sensitivity, down hydraulic gradient of the bunds to the east of the development are the Moor Grit, Scarborough and Cloughton Secondary A aquifers, which are characterised as of medium sensitivity.

6 QUALITIVATIVE HYDROGEOLOGICAL RISK ASSESSMENT

A qualitative hydrogeological risk assessment was presented in the FWS report (Ref 1), in respect of the completed Section 73 amended mine development, which provided a summary evaluation of the potential physical and chemical impacts of the long term operational condition of the mine site on the above sensitive hydrogeological receptors. That report concluded that for the operational condition the magnitude of physical and chemical effects of the modified mine surface development on the ecological, spring and Secondary A aquifer receptors would remain as negligible to minor. As part of the Permit application, pollution modelling of the final footprint of the bunds would be undertaken.

Presented in Section 7 of this report are the results of the quantitative modelling undertaken to evaluate the long term cumulative effects of the surface mine development works on groundwater levels and spring flows and their impacts on Moorside Farm Spring, Soulsgrave Farm Spring and to the Spring Flush area of the SAC.

7 QUANTITATIVE HYDROGEOLOGICAL MODELLING

To evaluate the magnitude of the potential adverse impacts on groundwater levels and to spring flows sustaining the sensitive receptors, identified in Section 5, quantitative Dynamic and Steady State modelling has been carried out by ESI Ltd (ESI) in the following two principal stages:-

- Stage 1 – Calibrating a "Base Case" model to represent the predevelopment baseline conditions.
- Stage 2 - Evaluation of the cumulative hydrogeological physical effects of the long term operational mine development to highlight potentially unacceptable adverse impacts on the key sensitive receptors and to determine whether additional mitigation measures are warranted.

In the following sections, details are provided on the conceptual models developed to evaluate the impact of the long term operational mine development, the groundwater modelling approach adopted and the model runs undertaken. The results of the multi-layered quantitative analysis of the simulated physical changes in groundwater levels in the Moor Grit and Scarborough aquifers and of the spring flowrates at Moorside Farm and Soulsgrave Farm springs, are summarised in Section 7.4 of this report and present in full in Appendix 2.

7.1 Conceptual Models

Full details of the conceptual hydrogeological model are given in Section 2 and 3 of the ESI report (Appendix 2), including geological cross-sections of the site showing the aquifer units affected by the development.

7.1.1 Pre-Construction Baseline Conditions

The model area is shown in Figure 2.1 for the Moor Grit aquifer and Figure 2.2 for the Scarborough aquifer (Appendix 2). The model has an active area of approximately 3.7 km east-west, 6.2 km north-south and the model grid cells are 20 m x 20 m in size. A refined grid area, where the model cells are 2 x 2 m in size, was adopted for the re-infiltration trench location west of Bund C and the reduced recharge areas into the Moor Grit created by the Shaft Platform, the Working Platform and Batching Plant surfaced areas, and by the landscaped bunds.

The superficial deposits, which are primarily cohesive and of a low permeability, are considered as non-aquifer units and cannot be modelled. As such, the model does not apply to the superficial deposits present on both the minesite and the SAC, and the simulated changes in groundwater levels are representative of those occurring in Moor Grit and Scarborough aquifers only.

The external model boundaries for the two main aquifer units are shown in Figure 2.1 and 2.2 (Appendix 2). The Moor Grit and Scarborough have drain cells to the west, north and east, with a recharge boundary to the south. The drain cells are used to simulate both spring discharges and discharge from the aquifer outcrop edges (which include transfers from an upper to a lower aquifer unit).

7.1.2 Construction Conditions

The long term mine construction features that are expected to impact on groundwater levels and spring flows have been simulated in the following worst case model. The conservative assumptions made on the construction elements are listed below and illustrated in Drawing 1433DevOD292 Appendix 1 and Figures 2.1 and 2.2 of ESI's model Appendix 2.

1. Areas occupied by bunds C, D, E and F, lined ponds, areas of hardstanding and buildings, the laydown area, welfare area, and shaft platforms have been treated as "No Recharge Zones."

2. Areas of bunds A, B and G, capped with restoration soils only, are treated as with a conservative reduced recharge of 10% of background recharge (equivalent to 20 mm/a).

3. Lined shaft basement construction features at the Service Shaft and Production Shaft to around 5.5 m below ground level have been modelled as impermeable. To more accurately represent the basements in the model, layer one (the Moor Grit Formation) was

split in half to form two layers and the no flow boundary condition for the basement was only added to the uppermost layer.

4. Three diaphragm walls at the Service, Production and MTS shafts, with outside diameters of 37.8 m, 34.8 m and 11.05 m respectively. Each of these diaphragm walls will be 1.2 m thick and will be installed to 60 m depth keyed into the Ellerbeck Formation. These have been simulated as No Flow boundaries to the base of the Cloughton Formation.

5. Three lined shafts to 120 m depth and 11 m diameter at each of the three shaft locations. These have been simulated as No Flow boundaries to the base of the Saltwick aquifer.

6. A re-infiltration trench that will collect runoff from the catchment shown in Arup Drawing YP-P2-CX-509 and recharge into the Moor Grit Formation. The re-infiltration trench is assumed to be excavated into the Moor Grit Formation rock head. An upper limit to the recharge along this trench was calculated based on the catchment area (approximately 6.5 ha) of the re-infiltration trench and effective precipitation. To prevent groundwater flooding along the re-infiltration trench, drain cells were placed along the trench outline in layer one.

7.2 Modelling Approach

The groundwater modelling has been undertaken using the USGS numerical finite difference groundwater model code MODFLOW-2005, using the Groundwater Vistas 6 (GV6) interface. A modified version of MODFLOW-2005 (MODFLOW-USG) called MODFLOW-USG, has also been used which allows for the use of unstructured grids. The following model runs were undertaken for both the pre-development base case and post-development models:

- One steady state model run with background recharge at calibrated levels. This run was undertaken to determine the Long Term Average (LTA) change in groundwater levels and spring flows as a result of the construction features forming the post-development landform; and
- One dynamic steady state model run to determine the maximum and minimum changes in spring flows and groundwater levels through a typical year using a typical synthetic recharge sequence to allow typical seasonal changes in water levels to be shown.

Full details of the model construction, parameter setting, input parameters and model calibration are presented in ESI's report (Appendix 2).

7.3 Steady State and Dynamic Conditions Modelled

For the long term steady state conditions, the post development construction features have been imposed onto the pre-development base case model. In addition, surface water discharge into the re-infiltration trench was decreased from the maximum calculated value for the catchment until unacceptable groundwater flooding was not observed in the model. The recharge rate for the model cells, representing the re-infiltration trench, was calculated to be 27,710 mm/a (approximately 140 times background recharge) at steady state conditions. This was then used in the model to obtain the steady state post-development model results that are representative of Long term Average (LTA) post-development conditions.

For evaluation of the long term average seasonal variation conditions, the dynamic steady state base case and post-development steady state models were both converted to transient simulations and run for several years until dynamic steady state had been achieved. For the purposes of this study, dynamic steady state is defined as the point at which the amplitude of seasonal groundwater fluctuations does not change. From this modelling, it was determined that dynamic steady state conditions could develop after a period of six years after completion of the operational landform.

For the dynamic model runs the initial heads derived from the steady state models were used. A synthetic recharge sequence was derived from MORECS data and long term monthly rainfall at Whitby to model a total annual recharge equivalent to the steady state calibrated model recharge of 200 mm/a. Zero recharge was applied over the summer period (June to September, inclusive), which is consistent with rainfall experienced on site during recent summers. On a similar basis a synthetic sequence was developed to represent monthly recharge into the re-infiltration trench with low recharge during summer months and high recharge over the winter months (November to March) so that the total annual recharge was equivalent to that used in the steady state model.

To enable evaluation of the magnitude of physical impacts at the key sensitive groundwater receptors described above, the following existing monitoring locations and dummy points were considered in the simulations, as shown in Figure 3.1 and 3.2 (Appendix 2) for the Moor Grit and Scarborough aquifers respectively:-

- Spring Flush Receptor: the impacts on groundwater level changes in the Moor Grit strata were considered by simulated changes at Assessment Points SAC 6, 7 and 8 (at well GW133A/HG111A) and at existing wells GW130 and 131.
- Moorside Farm Spring Receptor: the impacts on groundwater level changes in the Moor Grit strata were considered by simulated changes at Assessment Points SAC 6, 7 and 8 (at well GW133A/HG111A) and at existing wells GW130 and 131.
- Soulsgrave Farm Spring Receptor: the impacts on groundwater level changes in the Scarborough strata were considered at the intermediate well position GW112/HG119 from the simulated impacts on spring flows at SF2.

7.4 Model Results

Impacts on Ground Water Levels

The results of the Steady State modelling have been compared with the baseline conditions for the Moor Grit and Scarborough Formations. This shows that the greatest fall in groundwater levels in the Moor Grit occurs in two depressions and is counteracted by the re-infiltration trench in the centre of the site that locally increases groundwater levels between the areas of reduced and zero recharge.

Decreases in groundwater level reach approximately 2 m to the north west of the Shaft Platform and 2.9 m around Bunds C and D, and the Welfare area. Due to the relatively large areas of no recharge zones, the steady state decline in groundwater levels is simulated to cover almost the entire minesite area, except local to the re-infiltration trench. Around the Spring Flush and

Moorside Farm Spring area, this effect reduces to a fall in groundwater levels of less than 0.05 m due to the recharge to the spring source sustained by the re-infiltration trench.

From the dynamic state modelling of seasonal changes in the Moor Grit aquifer, which sustains the Moorside Farm Spring and the Spring Flush terrestrial ecosystem, the following changes in ground water levels are simulated to occur at the locations shown in Figure 3.1 (Appendix 2):-

- A 1.03m to 1.81 m rise in groundwater levels (between March to January) above baseline conditions SAC 6 located 200m from Moorside Farm Spring.
- A 0.61m to 1.25m rise in groundwater levels (between April to January) to above baseline conditions at SAC 7 located 115m from Moorside Farm Spring.
- A 0.07m to 0.19m fall in summer groundwater levels at GW133A located 80m from Moorside Farm Spring.
- A 0.17m to 0.32m fall in summer (July to September) groundwater levels at SAC 8 located 125m from Moorside Farm Spring.
- A negligible <0.05m fall in groundwater levels at Moorside Farm Spring.

As illustrated by the baseline data (Drawing 1433DevOD232 Appendix 1), during the summer to autumn period, groundwater levels in the Moor Grit at Moorside Farm Spring (GW133A / HG111A) typically fluctuate by around 1.5m. The modelling locations that best represent the groundwater level changes immediately uphydraulic gradient of the spring and forming its primary source area are best represented by the triangle of modelled nodes at MF2 at the spring, GW113A 80m to the southeast, SAC 8 125m south west and SAC 7 115m to the north east (Figure 3.1 Appendix 2). From this triangle of nodes, the simulated groundwater level changes over the summer autumn period at SAC 7 and 8 around 120m, uphydraulic gradient of the spring, will vary between a minimum rise of 0.61m to a maximum fall of 0.32m at SAC 8. This indicates that the re - infiltration trench will provide adequate recharge into the Moor Grit Aquifer. This demonstrates that the simulated groundwater level change in the Moor Grit Aquifer at the spring is very low in comparison with the magnitude of seasonal variation in the groundwater levels at this location. Therefore, as the spring is sourced primarily from runoff from the superficial deposits, with only a minor contribution from the Moor Grit Aquifer, the small change in groundwater levels caused by the minesite development will have no significant impact to spring flows. This condition is supported by the results of the spring flow rate simulations discussed below and equates to a local very low magnitude of change against the natural baseline seasonal variation, which is considered to represent a negligible significance of impact on this receptor.

In the Scarborough aquifer, the simulated groundwater level changes at GW136, within the same zone of groundwater level impact as the spring at Soulsgrave Farm, demonstrate a steady state impact of 0.27m. When compared with the annual seasonal groundwater level fluctuation monitored in the Scarborough in HG119/GW112 and GW 115, of 1.3m and 1.5m respectively (Ref. 1), this equates to a local low magnitude of change against the natural baseline seasonal variation, which is considered to represent a minor significance of impact on this receptor.

<u>Impacts on Spring Flow Rates</u>

As illustrated in Figure 3.9 (Appendix 2) and demonstrated from the baseline hydrogeological monitoring (Drawing 1433DevOD232 Appendix 1), the long term changes in recharge to Moorside Farm spring is simulated to cause a very low reduction in spring flow rate over the May to October period of up to 4.9×10^{-3} l/s (0.42 m^3/day). As illustrated in Drawing 1433DevOD232, during this summer to autumn period of low recharge conditions, baseline monitoring has typically recorded intermittent spring flow rate discharges at this location of around 0.03 l/s, although varying between no flow and peak of 0.06 l/s, which is a very small change in comparison with the measured seasonal range in flow rates. Such a very low reduction in spring flow rate over the May to October period of up to 4.9×10^{-3} l/s would be beyond the resolution of measurement in the field, and would therefore not be noticeable either too the domestic water supply or the spring flush area.

Simulated reductions in spring flow rate changes at Soulsgrave Farm Spring due to the long term changes in recharge to the Scarborough Formation are simulated to cause a relatively consistent very low reduction in spring flow rates of up to 6.2×10^{-3} l/s (0.54 m^3/day). Baseline monitoring has determined that seasonal flows vary between 0.1 and 1.0 l/sec during the winter months, 0.02 and 0.7 l/sec during the spring months, no flow to 0.6 l/sec during the summer months, and no flow to 0.53 l/s during the autumn months. As such, the simulated changes in spring flows at this location, caused by the proposed long term operational conditions is less than 1% of the measured winter season fluctuation in flow rates and less than 10% of the measured summer seasonal range in flow rates. Such changes would be beyond the resolution of measurement in the field, and would therefore not be noticeable.

7.5 Conclusions

The results of the multi-layered Transient and Dynamic State modelling undertaken by ESI has determined that the cumulative and long term effects of the development will cause a very low physical change in the groundwater levels in the Moor Grit or Scarborough Formations underlying the hydrogeologically supported Spring Flush ecosystem and a low physical change in the groundwater levels and spring flow rates at the Moorside and Soulsgrave Farm spring water supplies. This very low change in groundwater levels is typically at times of the year when groundwater levels are low and where flow from the Spring Flush has been observed to be intermittent and dominated by contribution of recharge to the Moorside Farm Spring via superficial deposits which would not be affected by minesite development.

On the basis of this modelling, it has been confirmed that there is no requirement for any additional groundwater control measures to be implemented as part of the final minesite development to mitigate physical impacts on groundwater levels or spring flow rates on sensitive receptors.

R IZATT-LOWRY
DIRECTOR

8 REFERENCES

1 FWS Consultants Ltd, 2017 Hydrogeological Risk Assessment For The Section 73 Works at Woodsmith Mine (1433OR226).

2 ESI, 2017. York Potash: Groundwater Modelling to evaluate the cumulative and long term impact of the operational development corresponding to the Section 73 Application Works (Ref 61415R9 D2, August2017).

3 FWS Consultants Ltd, 2016. Hydrogeological Baseline Report for the Doves Nest Farm Minesite, North Yorkshire 2012 to 2016 (1975OR01).

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5 FWS Consultants Ltd, 2017 Hydrogeological Risk Assessment for the Phase 2 Works at Doves Nest Farm Minesite, North Yorkshire (1433OR27).

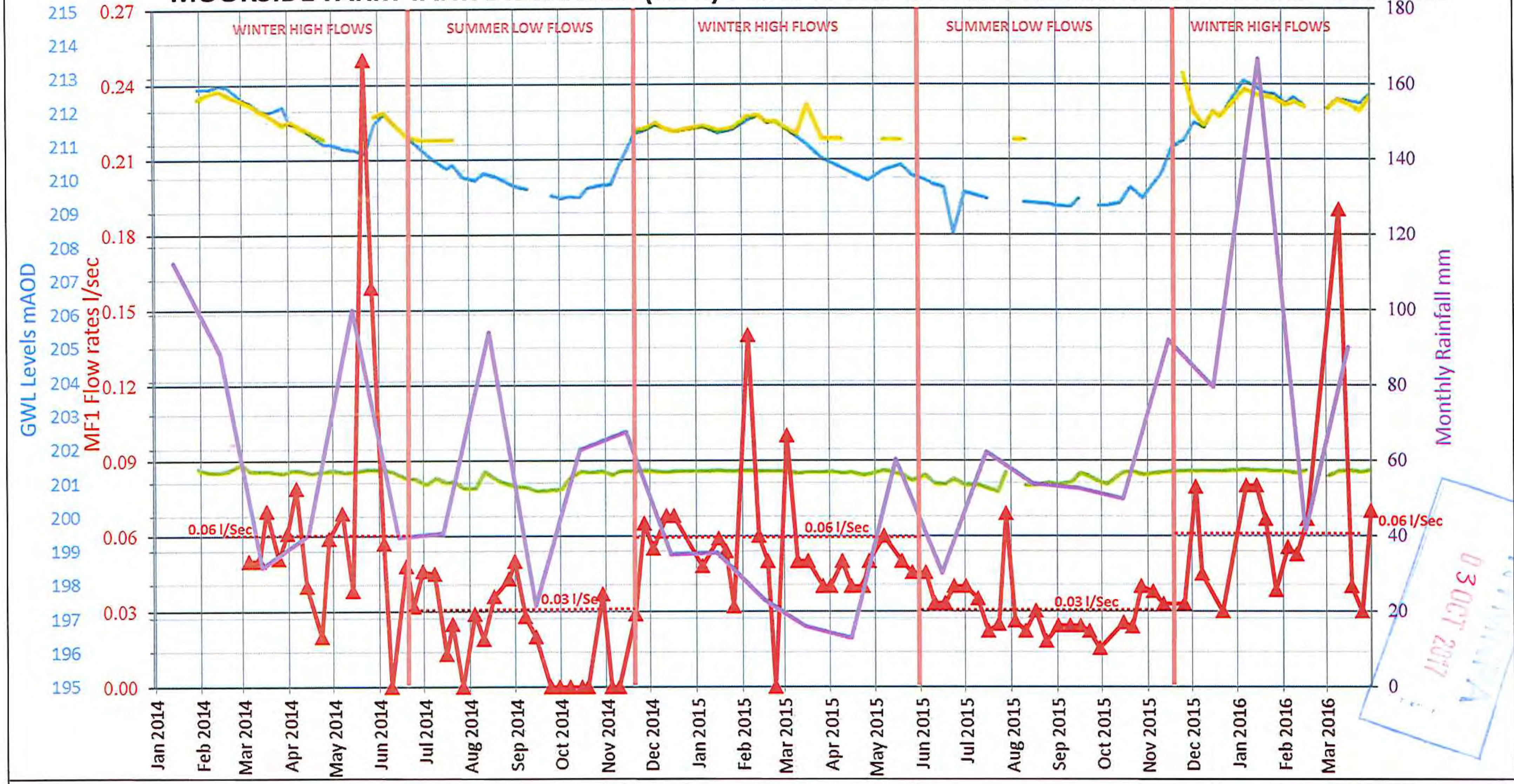
6 FWS Consultants Ltd, 2017 Hydrogeological Risk Assessment for the Phase 3 Works at Doves Nest Farm Minesite, North Yorkshire (1433OR175).

7 FWS Consultants Ltd, 2017 Hydrogeological Risk Assessment for the Phase 4 Works at Doves Nest Farm Minesite, North Yorkshire (1433OR205).

APPENDIX 1

DRAWINGS

MOORSIDE FARM TANK DISCHARGE (MF1) FLOW RATES VS GROUNDWATER LEVELS AND RAINFALL



NOTES / KEY

DISCHARGE FLOW RATES FROM SPRING FED TANK OVERFLOW (MF1)

SEASONAL AVERAGE FLOW RATES AT MF1

GROUNDWATER LEVEL IN MOOR GRIT UP HYDRAULIC GRADIENT OF MF2 (HG111A)

GROUNDWATER LEVEL IN SUPERFICIAL DEPOSITS UP HYDRAULIC GRADIENT OF MF2 (HG111)

GROUNDWATER LEVEL IN SUPERFICIAL DEPOSITS DOWN HYDRAULIC GRADIENT OF MF2 (HG112C)

MONTHY RAINFALL (WHITBY METEOROLOGICAL DATA

DRAWING TITLE

Moorside Farm Tank Discharge (MF1) Proxy for Moorside Farm Spring (MF2) Flow Rates VS Groundwater Levels and Rainfall

PROJECT TITLE

York Potash Project

CLIENT: Sirius Minerals plc.	
STATUS: FINAL	PROJECT NUMBER: 1433Dev
DRAWN BY: CB	DATE: December 2016
SCALE: NOT TO SCALE	DRG. No.: 1433DevOD232Rev1

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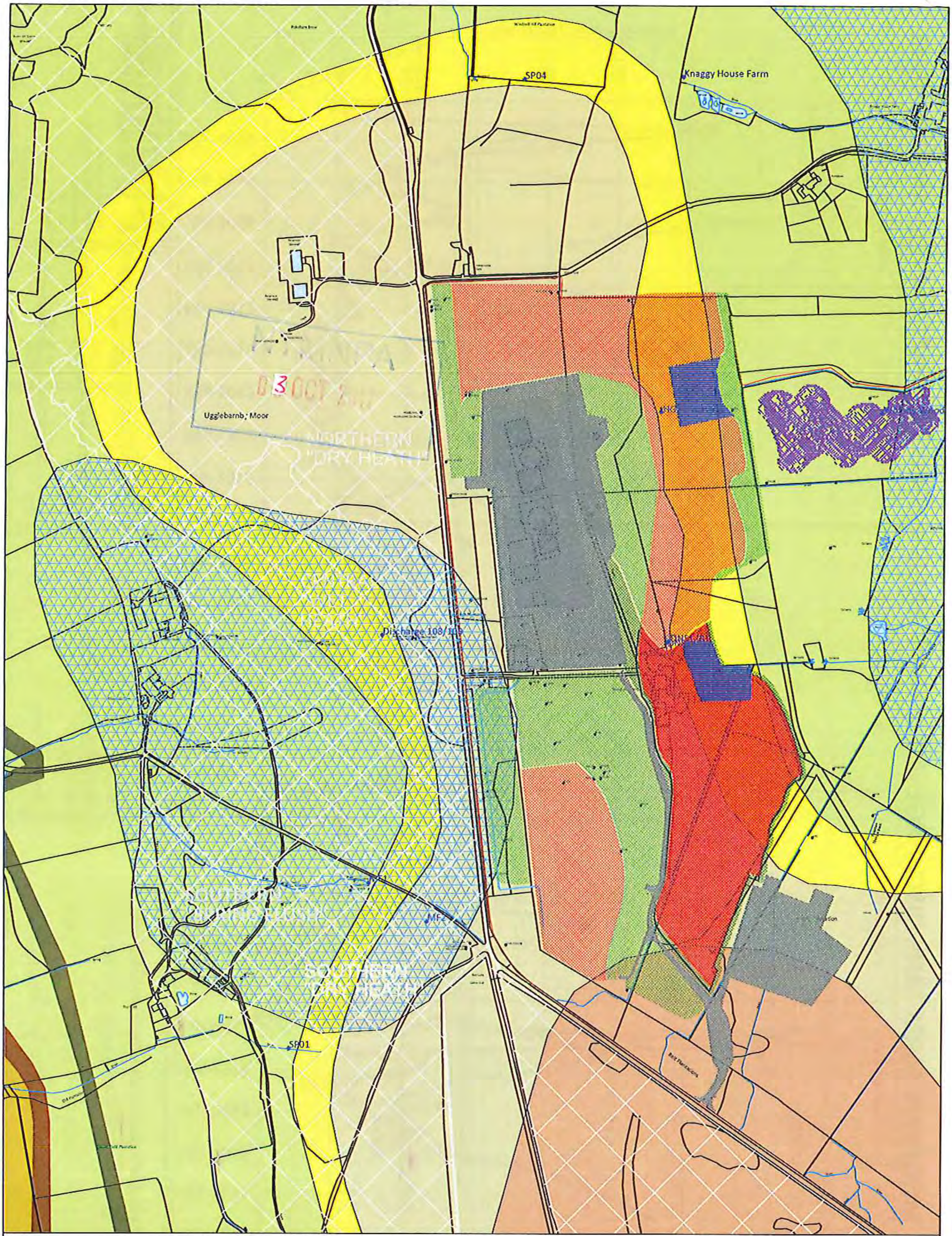

NOTES / KEY

SITE OWNERSHIP BOUNDARY
NYM SAC
SURFACE WATER
BOREHOLES
HYDROGEOLOGICAL RECEPTORS

AREAS OF NO RECHARGE
Shaft Platform & Welfare
NHNI MWFs Bunds
Ponds

AREAS OF POTENTIAL RECHARGE
Inert Bunds

GEOLOGY
GLACIAL TILL
LONG NAB
MOOR GRIT
SCARBOROUGH FORMATION
CLOUGHTON & SALTWICK FORMATION
ELLER BECK FORMATION
DOGGER FORMATION
WHITBY MUDSTONE

GROUNDWATER DRAINAGE

REINFILTRATION TRENCH

DRAWING TITLE	GEOLOGICAL PLAN AND EXPLORATORY HOLE LOCATIONS WITH MINESITE
PROJECT TITLE	YORK POTASH PROJECT
CLIENT	SIRIUS MINERALS PLC
STATUS	FINAL
PROJECT NUMBER	1433Dev
DRAWN BY	PG
DATE	AUGUST 2017
SCALE	1:5,000@A3/1:2,500@A1
DRG. No.	1433DevOD292

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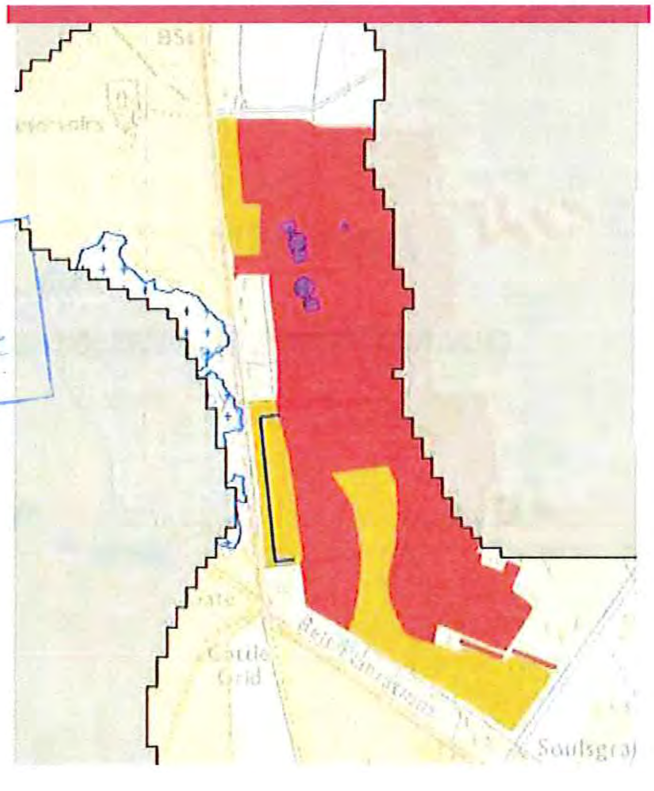
APPENDIX 2

QUANTITATIVE MODELLING



Groundwater Modelling to evaluate the long-term impact of the Woodsmith mine development to meet Section 73 Application requirements

Environment Specialists

Groundwater Modelling to evaluate the long-term impact of the Woodsmith mine development to meet Section 73 Application

Prepared for

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Report reference: 61415R9 D2, October 2017
Report status: Final Report

03 OCT 2017

Confidential
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Groundwater Modelling to evaluate the long-term impact of the Woodsmith mine development to meet Section 73 Application

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61415R9. Final Report

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Revision record:

Issue	Report ref	Comment	Author	Checker	Reviewer	Issue date	Issued to
1	61415R9 D1	Draft report for external review	CDW	HRS	MJS	16/08/2017	Richard Izatt-Lowry (FWS)
2	61415R9 D2	Draft report for external review	CDW	HRS	MJS	17/08/2017	Richard Izatt-Lowry (FWS)
3	61415R9	Final Report	CDW	BCH	BCH	2/10/2017	Richard Izatt-Lowry and Jennifer Cooke (FWS)

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FIGURES

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APPENDICES

1 INTRODUCTION

1.1 Background

Since approval of the scheme detailed in planning permission NYM/2014/0676/MEIA at Woodsmith Mine, modifications have been undertaken to the application documentation to address design amendments. These modifications have included amendment and revision to the foreshafts, substructures, drift portal, tunnel and to the earthworks aspects of the mine surface development.

This document presents the results of groundwater modelling undertaken to evaluate the long term impacts on groundwater levels and spring flows caused by the final operational minesite development landform, incorporating the current development design changes to the substructures and earthworks elements as detailed in the Hydrogeological Risk Assessment for the Section 73 Works at Woodsmith Mine (FWS 2017).

1.2 Scope and Objectives

ESI Limited (ESI) has been engaged by FWS Consultants Limited (FWS) to simulate the long term effects of the final operational mine site development.

This modelling report has been undertaken to evaluate the long term impact on groundwater levels and spring flows using the updated model to provide supplementary information, in support of the Section 73 Application.

The scope of work undertaken for this modelling includes:

- Generating new predictive groundwater flow models to account for the long term mine construction elements as shown in ARUP drawings. 40-ARI-WS-71-CI-DR-1036, 40-SMP-WS-10-PA-DT-0001 and YP-P2-CX-509.
- Processing the groundwater model results to determine predicted groundwater level and spring flows changes at neighbouring receptors with a focus around the Spring Flush area of the Ugglebarnby Moor Special Area of Conservation (SAC), and spring flows from Moorside Farm and Soulsgrave Farm springs;
- Sensitivity and uncertainty analyses to assess the suitability of the model results obtained; and
- Production of a groundwater modelling report to reflect the long term construction elements and modelling results (this report).

1.3 Data Sources

The updated groundwater flow model as described by ESI (2017a) has been adapted and used to predict the long terms effects of the mine works to meet Section 73 requirements. This has been undertaken using the following data sources:

- York Potash: 2017 Groundwater Model Update (ESI, 2017a) (Appendix A); and
- ARUP drawings. 40-ARI-WS-71-CI-DR-1036, 40-SMP-WS-10-PA-DT-0001 and YP-P2-CX-509.

1.4 Report Outline

This report is split in the following manner:

- Section 2 includes a description of the relevant long term construction elements, how these have been incorporated in the model and the model runs undertaken.
- Section 3 presents figures and tables to show simulated changes in groundwater levels and spring flows from the predicted baseline conditions due to the final landform and mine site construction features, as documented in the Section 73 Application.

- Section 4 provides a summary of the conclusions and key results.
- Appendix B provides details of the sensitivity and uncertainty analyses undertaken as part of this modelling work.