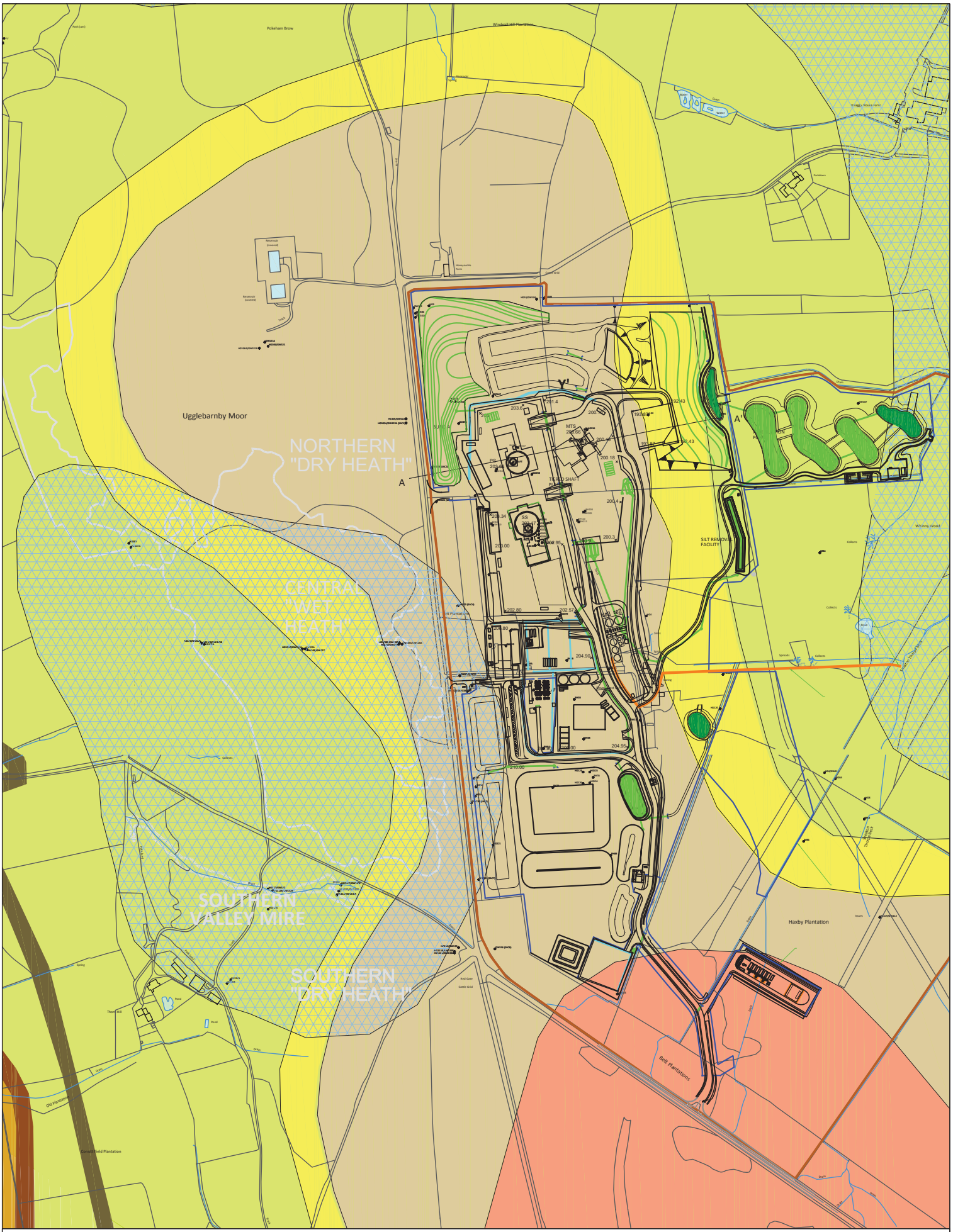

NOTES / KEY

SITE OWNERSHIP BOUNDARY
NYM SAC
SURFACE WATER
BOREHOLES GCBH01
HYDROGEOLOGICAL RECPTORS MF2
LINE OF CROSS SECTION
CROSS SECTION A-A' DRAWING 1433DevOD406

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

DRAWING TITLE
GEOLOGICAL MAP AND LINE OF CROSS SECTIONS

PROJECT TITLE
NORTH YORKSHIRE POLYHALITE PROJECT

CLIENT
SIRIUS MINERALS PLC

STATUS
FINAL

PROJECT NUMBER
1433Dev

DRAWN BY
CM

DATE
JULY 2019

SCALE
1:5,000@A3/1:2,500@A1

DRG. No.
1433DevOD407

FWS Geological & Geo-Environmental Consultants
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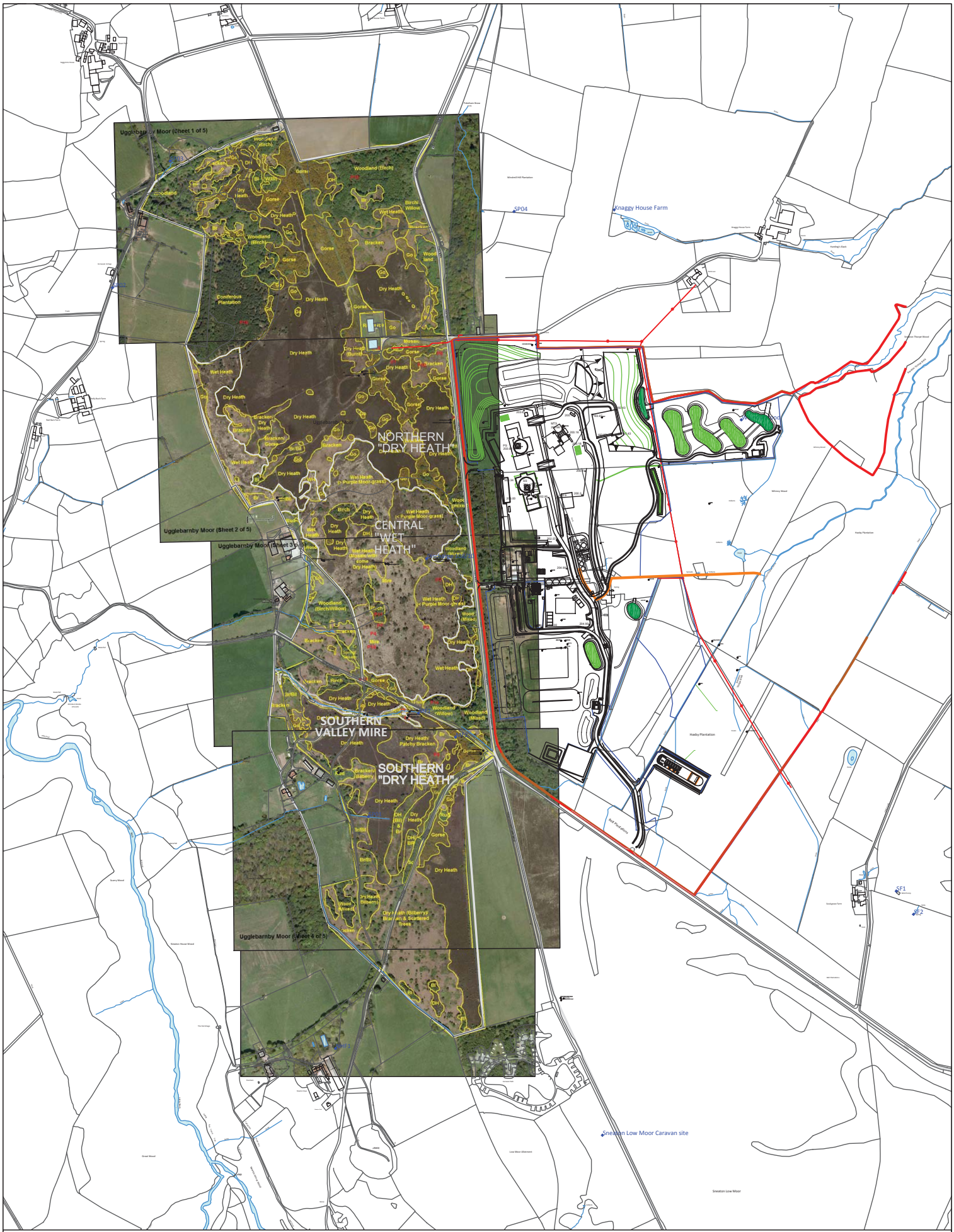

NOTES / KEY

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SURFACE WATER

BOREHOLES GCBH01

HYDROGEOLOGICAL RECEPTORS MF2

DRAWING TITLE
HYDROGEOLOGICAL RECEPTORS AND ECOLOGICALLY SENSITIVE HABITATS ON UGGLEBARNBY MOOR - PHASE 11

CLIENT
SIRIUS MINERALS PLC

STATUS
FINAL

PROJECT NUMBER
1433Dev

PROJECT TITLE
NORTH YORKSHIRE POLYHALITE PROJECT

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DRG. No.
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FWS Geological & Geo-Environmental Consultants
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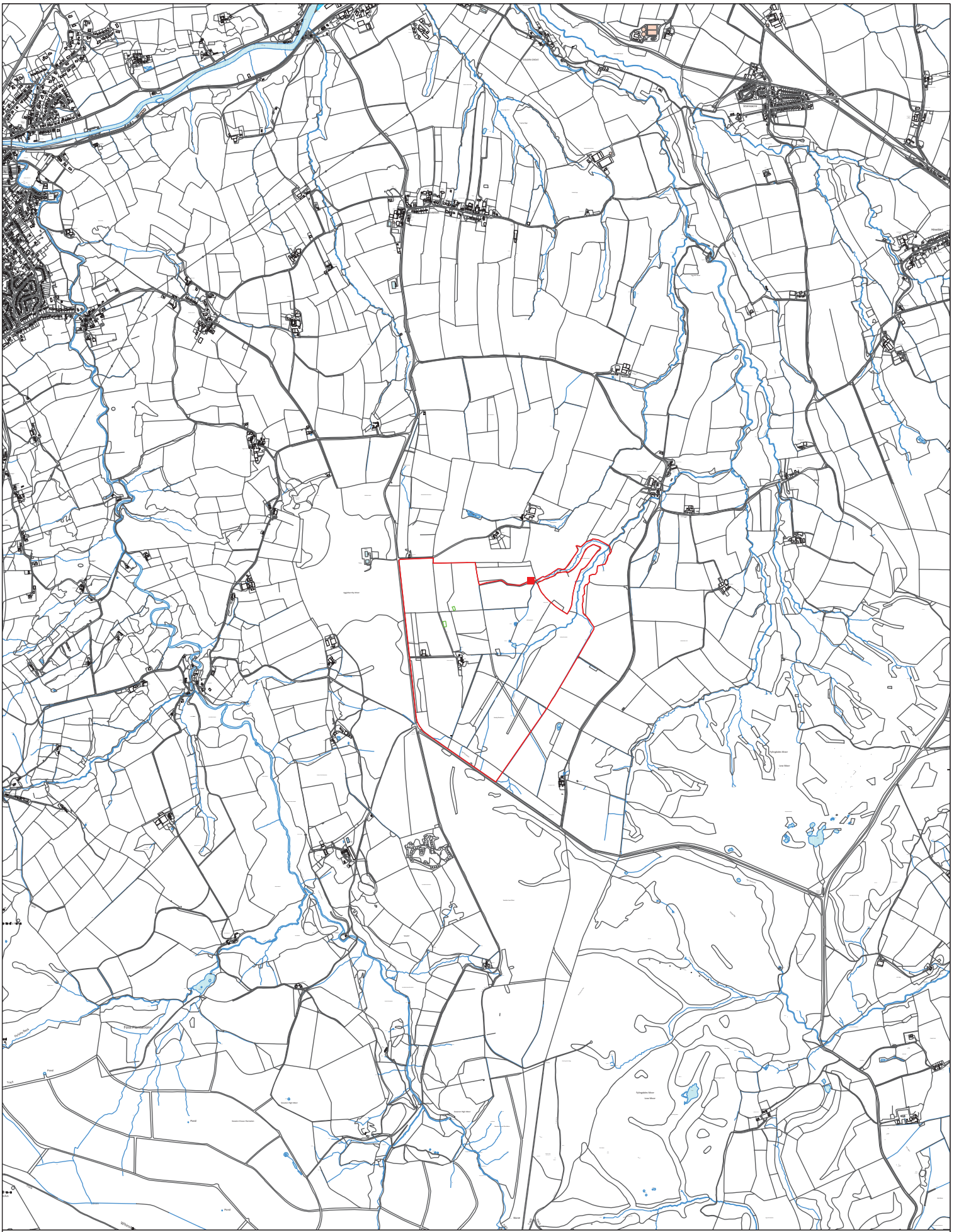

NOTES / KEY

SITE OWNERSHIP BOUNDARY

DRAWING TITLE

WOODSMITH MINE
LOCATION PLAN

PROJECT TITLE

YORK POTASH PROJECT

CLIENT
SIRIUS MINERALS PLC

STATUS
FINAL

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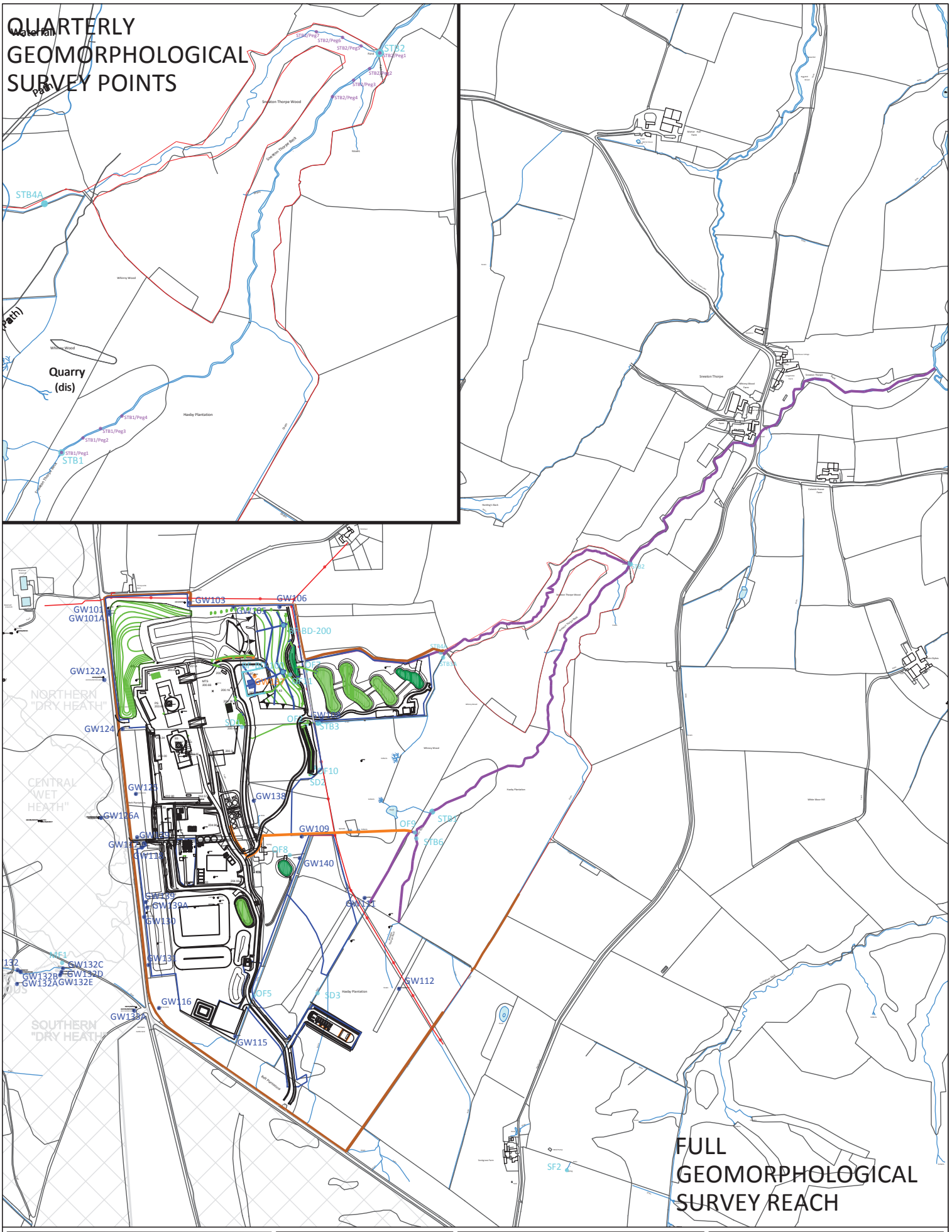

NOTES / KEY

SITE OWNERSHIP BOUNDARY
NYM SAC
SURFACE WATER
BOREHOLES GCBH01
SURFACE WATER MONITORING LOCATIONS SD1
GROUNDWATER MONITORING LOCATIONS GW132
LOCATION TO BE DECOMMISIONED GW137
GEOMORPHOLOGY SURVEY

DRAWING TITLE

PHASE 11 SURFACE AND GROUNDWATER QUALITY MONITORING POINTS

INSET - QUARTERLY GEOMORPHOLOGICAL SURVEY REACH

PROJECT TITLE
NORTH YORKSHIRE POLYHALITE PROJECT

CLIENT
SIRIUS MINERALS PLC

STATUS	PROJECT NUMBER
FINAL	1433Dev
DRAWN BY	DATE
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SCALE 1:8,000@A3 Inset 1:5,000@A3	DRG. No. 1433DevOD410 REV01

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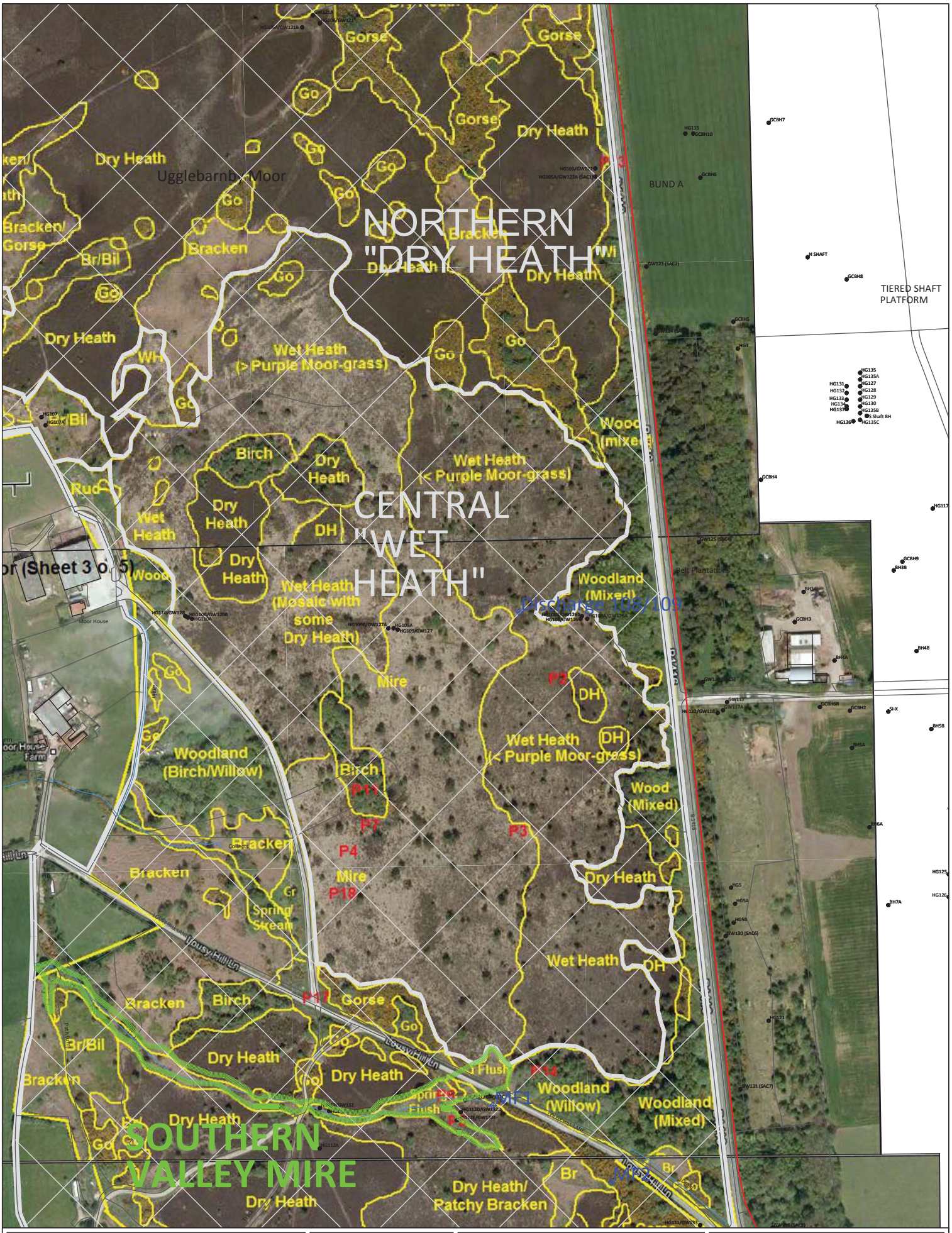

NOTES / KEY

SITE OWNERSHIP BOUNDARY

NYM SAC

SURFACE WATER

BOREHOLES GCBH01

HYDROGEOLOGICAL RECEPTORS MF2

SPRING FLUSH MONITORING AREA

DRAWING TITLE

VALLEY MIRE MONITORING AREA

PROJECT TITLE

YORK POTASH PROJECT

CLIENT
SIRIUS MINERALS PLC

STATUS
FINAL

PROJECT NUMBER
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1433DevOD411

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NYMNPA

29/07/2019

SIRIUS MINERALS PLC

Project Title / Facility Name:

North Yorkshire Polyhalite Project

Document Title:

GROUNDWATER MANAGEMENT SCHEME (NYMNPA 47 - PHASE 11)

Document Review Status

- [x] 1. Reviewed – Accepted – Work May Proceed — By: Robert Staniland
- [ ] 2. Reviewed – Accepted As Noted, Work May Proceed, Revise & Resubmit — On: 26 Jul 2019 13:07
- [ ] 3. Reviewed – Work May Not Proceed, Revise & Resubmit
- [ ] 4. For information only

Rev.	Revision Date (dd mmm yyyy)	Reason For Issue		Prepared by	Verified by	Approved by
3	26-Jul-2019	Planning	PLA			
2	24-Jul-2019	Planning	PLA			
1	09-Jul-2019	Information	IFI			
0	30-May-2019	Information	IFI			

Document ID:

40-FWS-WS-70-WM-PL-0022

FWS Geological & Geo-Environmental Consultants

SIRIUS MINERALS PLC - DISCHARGE OF PLANNING CONDITIONS FOR PLANNING PERMISSION NYM/2014/0676/MEIA (AS VARIED BY NYM/2017/0505/MEIA), NORTH YORKSHIRE POLYHALITE PROJECT

CONDITION	NYMNPA 47
REPORT	GROUNDWATER MANAGEMENT SCHEME (NYMNPA 47 – PHASE 11)
SITE	PHASE 11 DEVELOPMENT WORKS AT WOODSMITH MINE, NORTH YORKSHIRE
DOCUMENT NUMBER	40-FWS-WS-70-WM-PL-0022 Rev 3

1433DevOR443Rev 03/July 2019

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FWS

PROJECT NUMBER	1433	
PROJECT TITLE	North Yorkshire Polyhalite Project	
CLIENT	Sirius Minerals Plc Resolution House Lake View Scarborough YO11 3ZB	
REPORT TITLE	Groundwater Management Scheme (NYMNPA 47 – Phase 11)	
REPORT REFERENCE	1433DevOR443	
DOCUMENT NUMBER	40-FWS-WS-70-WM-PL-0022 Rev 3	
REVISION	**Date**	**Approved**
REV03	26/07/19	RIL

CONTENTS

GROUNDWATER MANAGEMENT SCHEME (NYMNPA 47 – PHASE 11)

1 INTRODUCTION

1.1 General Background

This document has been prepared on behalf of Sirius Minerals Plc (Sirius Minerals) and provides the Groundwater Management Scheme for the Phase 11 Works at Woodsmith Mine as required to discharge Condition 47 of the North York Moors National Park (NYMNP) planning permission NYM/2014/0676/MEIA (as varied by NYM/2017/0505/MEIA).

1.2 Phase 11 Works

The scope of the Phase 11 Works includes: -

- Development of landscape mitigation screening;
- Tree clearance within Haxby Plantation;
- Sinking the MTS shaft via drill and blast method;
- Operation of the Galloway;
- Creation of a materials handling area;
- Installation of external silencer to the dust collector of the Service Shaft building;
- Installation of batteries.

1.3 Compliance with Conditions

Table 1 sets out the wording of Planning Condition 47 to Planning Permission NYM/2014/0676/MEIA (as varied by NYM/2017/0505/MEIA) and details where the relevant material is presented in the report to comply with this condition: -

Table 1 - Summary of Planning Condition 47 and where Relevant Details are provided in the Report

NYMPA Condition 47	Compliance with Condition 47
Following the approval of the Revised Hydro-Geological Risk Assessment but prior to the commencement of development, a Groundwater Management Scheme (covering construction, operation and post-operation phases), shall be submitted to and approved in writing by the Local Planning Authority in consultation with the Environment Agency.	This document 1433DevOR443/July 2019.
The Scheme shall include technical drawings detailing the conceptualised hydrogeology with the final detailed designs of the proposed mitigation measures outlined in the Environmental Statement and in accordance with the details in the York Potash Project: Habitats Regulations Assessment prepared by Amec Foster Wheeler dated June 2015 with document reference 35190CGos064R, and the final design details of the lining systems for the proposed shaft.	Final designs, technical details, a conceptualised hydrogeological cross section, plans of the mitigation measures, and details of the compliance monitoring and reporting to validate their implementation for the Phase 11 Groundwater Management Scheme are provided in Sections 2 and 3.
Development shall thereafter proceed only in strict accordance with the approved Scheme and a timetable to be included within it.	The timetable for implementing the Phase 11 Works Groundwater Management Scheme is presented in Section 4.

2 GROUNDWATER MANAGEMENT MEASURES – PHASE 11 WORKS

2.1 General

The Phase 11 Works include the following groundwater management measures: -

- Shaft construction:
    - Probe drilling and targeted grouting prior to shaft to limit inflows.
    - Blast design to minimise leachable unspent explosives in arisings generated.
    - Groundwater inflow management by sump pumping during shaft construction.
    - Groundwater inflow management through the drained liner by sump pumping of completed shaft.
- Construction of Bund F:
    - A granular piped basal drainage.
    - Restriction on size of working areas.
    - Engineered placement of the rock materials in Bund F.
    - Restoration soil layer to incorporate a land drainage system.
- Construction works undertaken to the CEMP (Ref 1).

To demonstrate the effectiveness of the groundwater management measures adopted during the Phase 11 Works, the ground and surface water monitoring scheme and associated remedial action plan will be implemented, as detailed in Ref. 2 and 3.

2.2 Shaft Construction

2.2.1 Probe Drilling and Grouting

Probe Drilling

Probe drilling will be undertaken to determine the magnitude of water flow from ungrouted sections. The drilling will extend 40 m ahead of the excavation, which will progress to within 5 m of the toe of the drill hole. The magnitude of water inflows from the drill holes will be determined to evaluate whether targeted grouting is required to enable excavation with sump pumping.

Grout Injection

Where drilling determines that treatment is required to reduce groundwater inflows, a grout curtain will be formed from a single ring of 150 mm diameter holes. This grouting process will be undertaken in descending 5 m stages to mitigate water/grout loss and bore hole collapse. Stage lengths will be shortened if persistent water loss or no flush return conditions arise.

Management of Drilling Arisings

All solid drilling arisings will be collected to a temporary stockpile for subsequent reuse as landscape fill within Bund F. All water flush arisings will be collected within drainage channels and recycled through a treatment plant prior to either reuse or discharge to the Non Domestic Wastewater Treatment Plant (NDWTP).

Validation of Grouting

Validation of the grout curtain will be undertaken by the volume, flow and pressure monitoring of each stage of the grouting process and by permeability tests on completion of grouting.

Specification

The grout mix will comprise standard, microfine cement, acrylate or polyurethane grouts will be used with superplasticizer and anti-washout additives.

The grout curtain will be formed by a single ring of primary injection holes drilled to form a 2 m wide low permeable zone around the perimeter of shaft excavation area with a permeability of less than 1×10^{-7} m/s.

Operational Management

The grout injection pressure will be selected, in accordance with BS5930:2015, to ensure hydrofracturing of the host strata is not induced. Before the stage grouting begins, a 5 minute pre-treatment permeability test will be carried out using an in-situ-packer for each stage, using a target pressure of 10 bar. Following grouting, a 10 minute post-treatment permeability test will be undertaken using an in-situ packer for each grouting stage at a target pressure of 10 bar. The process will be repeated if further treatment is needed.

2.2.2 Blast Management

Blast Design

Holes will be drilled on a grid pattern across the floor of the shaft excavation to a depth of 3.6 m to install the cartridge explosives. Blast design calculations have determined that around 500 kg of explosives will be used in each bench blast.

Drilling Blast Holes

The blast holes will be formed using rotary percussive water flush techniques. Prior to inserting the cartridge explosives into the drill holes, the base of the excavation will be pumped dry of the drilling and formation waters, which will be recycled, filtered and cleaned for reuse in the drilling process.

Specification of Explosives and Blast Management

Cartridge emulsion explosives will be used comprising an aqueous solution of ammonium nitrate and other oxidising agents within an oil phase comprising waxes, emulsifier and oil.

Quality control procedures will be adopted in the blast management process to limit the potential for mis-fire to occur. As such, the proportion of unspent explosives within the blast arisings will be maintained to less than 0.5% by mass per blast.

Following blasting, the arisings and formation/construction water will be excavated into a muck bucket, brought to the surface and placed on a bunded concrete pad handling area to assess its geotechnical condition. Materials determined to be geotechnically acceptable for placement as a Class 4 Landscape Fill will be transported for placement in Bund F as detailed in Section 2.3.3. Materials considered too wet, will be taken to the Materials Handling Areas and drained until they meet Class 4 acceptance criteria and then placed in Bund F, as detailed in Section 2.3.3.

2.2.3 Temporary Sump Dewatering

General

Temporary sump dewatering during shaft chamber construction will be undertaken, where necessary, to maintain the excavation dry.

Following completion of shaft lining to -146.2m OD, a temporary sump will be constructed in the shaft base to facilitate management of groundwater ingress through the drained liner during subsequent construction of the tunnel boring machine (TBM) launch chamber.

Operational Management

During shaft construction, sumps and drainage channels will be excavated in the bench levels to facilitate groundwater pumping, where necessary. Groundwater generated will be pumped to a settlement tank at surface level prior to either offsite disposal or treatment within the NDWTP for discharge to Sneaton Thorpe Beck in accordance with Environmental Permit EPR/LB3797VJ.

Documentation and Reporting

The Contractor will be responsible for maintaining daily records of the dewatering operations and of flow rates discharged from the system to offsite disposal or treatment within an onsite water treatment facility for discharge to Sneaton Thorpe Beck in accordance with the Environmental Permit's (EPR/LB3797VJ) reporting requirements.

2.2.4 Drained Shaft Liner

General

A drained reinforced concrete liner will be formed from 87m AOD to -157 m OD by top down construction. These concrete shaft liner pours will include permanent groundwater drainage pipe work through the liner.

Operational Management

During construction of the drained shaft liner and prior to commencement of the TBM launch chamber, sumps will be excavated in the shaft benches and final base level to facilitate groundwater pumping, as detailed in Section 2.2.3.

Documentation and Reporting

The Contractor will be responsible for maintaining daily records of the dewatering operations and of flow rates discharged from the drained liner system.

2.3 Construction of Bund F

2.3.1 Basal Drainage System

General

The basal drainage system to Bund F will comprise piped granular drains spaced at around 60 m intervals with additional groundwater collector drains installed at the locations of the former springs/seepages along the alignment of the Moor Grit and Scarborough Formation interface, as granted in the Environmental Permit EPR/MB3399VR 10/05/2019 York Potash Ltd. Runoff and Basal Drainage of Bunds at Woodsmith Mine. This system is to be constructed at a minimum gradient of 1 in 50 and will discharge to a perimeter drain on the eastern side of Bund F that will discharge via a transfer drain directly into a surface water perimeter swale.

Drainage from Bund F and Shaft Platform area will be directed to the northern attenuation ponds east of Woodsmith Mine Site and then discharged at a single point (Discharge OF8) to Sneaton Thorpe Beck, as granted in the Environmental Permit EPR/MB3399VR 10/05/2019.

Specification

The basal drainage layer is to be constructed to the following specification, as granted in the Environmental Permit EPR/MB3399VR 10/05/2019 and illustrated in Arup Drawings 40-ARI-WS-7100-CI-22-01060 and 40-ARI-WS-7100-CI-22-01064:-

- The subgrade will be prepared to remove all topsoil and subsoils to a depth of 0.6 m to prepare a formation with a minimum gradient of 1 in 50 and profiled drain runs.
- A basal geotextile, with a minimum pore size of 150 µm, burst resistance of 350 kPa, a Tensile Strength of 100 kPa, puncture resistance of 50 N and a permeability of > 100l/m^2/s, will be placed around the formation for each of the basal drains aligned in a herringbone arrangement of perforated 225 mm Ø HDPE PE80 SDR11 carrier pipes placed on a sand blinding layer and overlain by 0.5m of Type B drainage stone. All pipes are to be butt fusion welded and the Type B stone is to comply with Clause 505, Table 5/1 of the Specification for Highway Works, compacted in accordance with Table 6/4 method 3.
- The discharge point (OF8) of the basal drainage outflow to the swale will have a manhole cover and a mechanism to block the drain, as a temporary measure, if the quality of the groundwater breaches the pollution levels set out in the Groundwater and Surface Water Monitoring Scheme (Ref.2). This water will be pumped back for offsite disposal or

treatment through the NDWTP prior to discharge to Sneaton Thorpe Beck, in accordance with in Environmental Permit EPR/LB3797VJ.

Documentation and Reporting

The Contractor will compile "as built" records of the basal drainage system on completion.

2.3.2 Restricted Working Area

In accordance with Environmental Permit EPR/MB3399VR 10/05/2019, placement of the rock materials in Bund F is to be restricted to a 1 ha working area, at any one time, with an additional 1 ha of exposed arisings open to infiltration at any one time. The sequence and phasing of material placement and restoration of the bunds will progress from north to south.

2.3.3 Engineered Filling

General

The rock arisings excavated from the MTS Shaft will include pyritic mudstones sandstone, and siltstone and will be placed in Bund F as a compacted Class 4 engineered fill with the final profiled surface of the arisings compacted to form an upper 1 m thick low permeable layer of compacted clay or mudstone as shown in Arup Drawing 40-ARI-WS-7100-CI-18-01061.

Specification

In accordance with Environmental Permit EPR/MB3399VR 10/05/2019, the Class 4 Landscape Fill will be engineered to achieve a permeability of less than 1×10^{-7} m/s.

The Class 2 low permeable compacted clay or mudstone will be placed below the soil restoration layer to the earthworks specification, in accordance with Environmental Permit EPR/MB3399VR 10/05/2019, to form a 1m layer with a permeability of less than 1×10^{-9} m/s.

Construction Quality Assurance and Reporting

Construction quality assurance of the earthworks and reporting will be undertaken in accordance with the Environmental Permit EPR/MB3399VR 10/05/2019.

2.3.4 Restoration Layer

General

On completion of placing rock fill in Bund F, including the final profiled surface of the 1m thick compacted clay or mudstone, a restoration soil cover layer will be placed of between 0.8 to 2.0 m thick dependant on the final restoration planting scheme, as illustrated in Arup Drawing 40-ARI-WS-7100-CI-18-01061.

Specification

The specification for the soils used in the restoration layer and the seeding and vegetation will be as detailed in Landscape and Ecological Management Plan (Ref 4).

The land drainage constructed within the restoration layer will comprise 150 to 200 mm diameter perforated pipes within a gravel surround covering approximately 3% of the restored surface area. To maintain self-cleaning this system is to be placed at a minimum gradient of 1 in 50. The transfer collector drains from this system will discharge to a perimeter swale at the toe of each bund.

Construction Quality Assurance, Operational Management and Maintenance and Documentation and Reporting

Construction quality assurance, operational management and maintenance, and documentation and reporting on the restoration layer will be undertaken as detailed in the Environmental Permit EPR/MB3399VR 10/05/2019.

2.4 Construction Management Plan

The site works, operations and compounds for the plant and maintenance areas for the Phase 11 Works will be operated in accordance with the CEMP (Ref 1).

3 COMPLIANCE MONITORING

An Environmental Engineer will oversee implementation of the Groundwater Management Measures during the Phase 11 Works and undertake the inspections, reviews and reporting during construction of the works, as detailed in Section 2.

4 TIMETABLE FOR IMPLEMENTING THE PHASE 11 WORKS GROUNDWATER MANAGEMENT SCHEME

The timetable for undertaking the Phase 11 Works, including the associated groundwater management scheme, is September 2019 to February 2020.

R IZATT-LOWRY
DIRECTOR

5 REFERENCES

1 Construction Environmental Management Plan is 40-RHD-WS-70-EN-PL-0041.

2 FWS Consultants Ltd, 2019 Construction and Operation Phase Ground and Surface Water Monitoring Scheme for the Phase 11 Works at Woodsmith Mine, North Yorkshire (1433OR444).

3 FWS Consultants Ltd, 2019 Remedial Action Plan for the Phase 11 Works at Woodsmith Mine, North Yorkshire (1433OR445).

4 Landscape and Ecological Management Plan is 40-ESW-WS-8320-EN-PL-00001.

FWS Geological & Geo-Environmental Consultants

NYMNPA

29/07/2019

SIRIUS MINERALS PLC - DISCHARGE OF PLANNING CONDITIONS FOR PLANNING PERMISSION NYM/2014/0676/MEIA (AS VARIED BY NYM/2017/0505/MEIA), NORTH YORKSHIRE POLYHALITE PROJECT

CONDITION	NYMNPA 45 & 46
REPORT	HYDROGEOLOGICAL RISK ASSESSMENT (NYMNPA 45 & 46 – PHASE 11)
SITE	PHASE 11 WORKS AT WOODSMITH MINE, NORTH YORKSHIRE
DOCUMENT NUMBER	40-FWS-WS-70-WM-RA-00013 Rev 03

1433DevOR433Rev 02/July 2019

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PROJECT NUMBER	1433Dev			
PROJECT TITLE	North Yorkshire Polyhalite Project			
CLIENT	Sirius Minerals Plc Resolution House Lake View Scarborough YO11 3ZB			
REPORT TITLE	Hydrogeological Risk Assessment (NYMNPA 45 & 46 – PHASE 11)			
REPORT REFERENCE	1433DevOR433			
DOCUMENT NUMBER	40-FWS-WS-70-WM-RA-00013 Rev 03			
REVISION	**DATE**	**AUTHOR**	**CHECKED**	**APPROVED**
REV 03	26/07/2019	RIL	CM	RIL

CONTENTS

APPENDICES

HYDROGEOLOGICAL RISK ASSESSMENT (NYMNPA 45 & 46 – PHASE 11)

1 INTRODUCTION

1.1 General Background

This document has been prepared on behalf of Sirius Minerals Plc and provides the Hydrogeological Risk Assessment (HRA) for the Phase 11 Works at Woodsmith Mine. This is required to satisfy Condition 46 of the North York Moors National Park Authority (NYMNPA) planning permission NYM/2014/0676/MEIA (as varied by NYM/2017/0505/MEIA).

Previous documents prepared by FWS on the hydrogeology of the site and the phased construction works have included a revised Hydrogeological Baseline Report (Ref. 1), Hydrogeological Risk Assessments for the Phase 2, 3, 4, 4a, 5, 6, 6a, 7, 8, 9 and 10 Works (Refs. 2 to 11), The Hydrogeological Risk Assessment for the granted Environmental Permit for run-off and basal drainage from landscape mitigation screening (Permit number EPR/MB3399VR) (Ref. 12) and an assessment of the long term cumulative hydrogeological impacts, in support of the s73 application (Ref. 13).

1.2 Compliance with Conditions

Table 1 sets out the wording of Planning Conditions 45 and 46 to Planning Permission Ref. No. NYM/2014/0676/MEIA (as varied by NYM/2017/0505/MEIA) that relates to the Hydrogeological Risk Assessment and details where the relevant material, to comply with this condition, has been provided within this report:-

Table 1 – Summary of Planning Conditions 45 and 46 and Where Relevant Details Are Provided In This Report

PLANNING CONDITIONS RELATING TO IMPLEMENTATION OF THE RECHARGE TRENCH AND GROUNDWATER DRAINAGE	
NYMNP Condition 45	**Compliance with Condition 45**
Prior to the commencement of shaft sinking or chamber formation beneath ground at Doves Nest Farm site and in accordance with the details in the document "York Potash Project: Habitats Regulation Assessment" prepared by Amec Foster Wheeler dated June 2015 with document reference 35190CGos064R, and as updated by the HRA prepared by Royal Haskoning DHV dated November 2017 with document reference 40-RHD-WS-83-WM-RP-001 Rev 4, a programme for the implementation of the following shall be submitted to and agreed in writing with the MPA:- a. A recharge trench to promote re-infiltration of surface runoff to recharge the Moor Grit up hydraulic gradient of the source area to Moorside Farm Spring. b. Provision of groundwater drainage areas beneath bunds E and F to collect spring waters issues from the Scarborough and Cloughton Formations for discharge via the mine site surface water drainage system.	Comment on the requirement for implementation of the recharge trench and groundwater drainage beneath Bund F is presented in Section 7.

PLANNING CONDITIONS RELATING TO THE HYDROGEOLOGICAL RISK ASSESSMENT	
NYMNP Condition 46	**Compliance with Condition 46**
Prior to the commencement of each Phase of Construction at the Doves Nest Farm Minesite a revised Hydrogeological Risk Assessment based on the most up to date monitoring data shall be undertaken in accordance with the details in the document "York Potash Project: Habitats Regulations Assessment" prepared by Amec Foster Wheeler dated June 2015, with document reference 35190CGos064R and as updated by the HRA prepared by Royal Haskoning dated November 2017 with document reference 40-RHD-WS-83-WM-RP-0001 Rev 4; and submitted for approval in writing by the MPA in consultation with Natural England and the Environment Agency.	1. Details of the Works are presented in Section 3. 2. Up to date monitoring is presented in FWS Consultants Ltd 2016 Hydrogeological Baseline Report for the Doves Nest Farm Minesite, 2012 to 2016 (1975OR01 Ref. 1) and Woodsmith Mine Phase 2 to 4 – Groundwater, Surface Water and Ecological Monitoring Completion Report (Annual monitoring report for 2017; 40-SMP-WS-7322-WM-RP-00001), and Woodsmith Mine Annual Groundwater, Surface Water and Ecological Monitoring Report - 2018 (40-SMP-WS-7322-WM-RP-00010 in Production) 3. Details of the Hydrogeological Risk Assessment are presented in Section 6.

1.3 Objectives

The purpose of this document is to:-

- Provide details of the hydrogeology of the site and adjacent areas.
- Provide details of the Works and the groundwater control measures that will be implemented.
- Provide a qualitative assessment of the magnitude of risks to hydrogeological receptors from the Works undertaken concurrently with Phases 4a, 5, 6, 7, 8, 9 and 10 Works.

All details relating to the "as built" conditions, long term impacts and associated qualitative and quantitative modelling of the completed Service, Production and MTS shafts remain unchanged and are as addressed in detail in the Section 73 Works Hydrogeological Risk Assessments (Ref. 13).

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. 1).
- Groundwater Activity Permit Hydrogeological Risk Assessment for the Landscape Bund's (1433DevOR413 January 2019 (Ref. 12).

Development Details of Phase 11 Works

- Sirius Woodsmith Mine Phase 11 Construction Method Statement Document No. 40-SMP-WS-7100-PA-MS- (Ref. 15).
- Arup NYMNPA 60 Surface Water Drainage Scheme Phase 11 Works – 40-ARI-WS-7100-CI-RP-01007 (Ref. 16).
- Construction Environmental Management Plan - 40-RHD-WS-70-EN-PL-0041EMP.

- 40-ARI-WS-7100-CI-18-01061 – Phase 11 Earthworks.
- 40-ARI-WS-7100-CI-22-01055 – Phase 11 Masterplan.
- 40-ARI-WS-7100-CI-22-01057 – Phase 11 Drainage General Arrangement.
- 40-ARI-WS-7100-CI-22-01060 – Phase 11 Basal Drainage General Arrangement.
- 40-ARI-WS-7100-CI-22-01063 – Phase 11 Temporary Spoil Handling Area General Arrangement.
- 40-ARI-WS-7100-CI-22-01064 – Phase 11 Bund F Basal Drainage.

Environmental Permits

- Environmental Permit EPR/MB3399VR 10/05/2019 York Potash Ltd. Runoff and Basal Drainage of Bunds at Woodsmith Mine (Ref. 18).

3 DETAILS OF THE PHASE 11 WORKS

3.1 General Description

Construction of the Phase 7, 8, 9 and 10 works, as detailed in the Hydrogeological Risk Assessments (Refs. 8 to 11), are ongoing. Provided below are details of the Phase 11 Works that will be undertaken concurrently with ongoing works, as illustrated in the Phase 11 Masterplan Arup Drawing 40-ARI-WS-7100-CI-22-01055:-

- Development of landscape mitigation screening;
- Tree clearance within Haxby Plantation;
- Sinking the MTS shaft via drill and blast method;
- Operation of the Galloway;
- Creation of a materials handling area;
- Installation of external silencer to the dust collector of the Service Shaft building;
- Installation of batteries.

Tree clearance, operation of the Galloway and installation of the external silencer and batteries, will have no additional hydrogeological impacts above that previously addressed for previous construction phases and no site-specific hydrogeological risk assessment is required for these aspects of the works.

The following sections present details of the design levels and construction methodology for the Phase 11 Works.

3.2 Construction Methodology

3.2.1 Management of Landscaped Mitigation Screening

Management of the landscaped mitigation screening will be undertaken in compliance with Environmental Permit EPR/MB3399VR 10/05/2019. As part of the Phase 11 Works, a topsoil and subsoil strip will be undertaken to a depth of 0.6 m within the footprint of Bund F to accommodate construction of the concrete hardstanding Materials Handling Area and placement of extractive material from the MTS shaft construction Arup Drawings 40-ARI-WS-7100-CI-18-01061 and 40-ARI-WS-7100-CI-22-01055.

Extractive material, generated from the MTS shaft construction from 83 m AOD to -157 m OD will comprise materials excavated by drill and blast from the Whitby Mudstone Formation, Staithes Sandstone, Cleveland Ironstone Formation and Redcar Mudstone Formation, which are characterised (Ref. 12) as of low pollution potential. Blast arisings excavated from the shaft will first be placed in the material bunker adjacent to the headframe, to enable drainage of free water to be dealt with via the Non Domestic Wastewater Treatment Plant (NDWTP) route, prior to geotechnical assessment and placement in Bund F. It the material is too wet for placement; it will be transported to the Materials Handling Area to be mixed and work to a suitable grade. Drainage from the Materials Handling Area will discharge to the attenuation tank in the southeast corner of the Materials Handling Area, regulated by a penstock valve to control and enable cut off prior to discharge to the perimeter swale, as illustrated in Arup Drawing 40-ARI-WS-7100-CI-22-01063.

A basal drainage system will be constructed at formation level to drain the rock fill during placement and control long term groundwater head levels within the rockfill, as illustrated in Arup Drawings 40-ARI-WS-7100-CI-22-01060 and 40-ARI-WS-7100-CI-22-01064. It will comprise piped granular drains, installed on a 60 m spacing and conveying basal drainage via a carrier drain. Additional groundwater collector drains will be installed at the locations of the former springs/seepages along the alignment of the Moor Grit and Scarborough Formation interface beneath Bund F. To maintain self-cleaning, this system is to be placed at a minimum gradient of 1 in 50. This basal drainage system will have a perimeter drain on the eastern side of the bund that will discharge via a transfer drain directly into a surface water perimeter swale.

As approved under Environmental Permit EPR/MB3399VR (Ref. 17), drainage from Bund F will discharge to a sequence of attenuation ponds and then discharged at a single point (Discharge OF8) to Sneaton Thorpe Beck (Arup Drawing 40-ARI-WS-7100-CI-22-01057).

Placement of the rock materials within Bund F will be limited to a working area of 1 ha plus a 1ha area for capping at any one time. The fill will be compacted to reduce the air void content and achieve an average permeability of $1x10^{-7}$ m/s (Ref. 12). The sequence and phasing of material placement within the bunds will progress from north to south.

3.2.2 Sinking the MTS Shaft by Drill and Blast Methodology

3.2.2.1 Construction Sequencing

The following sequence of probe drilling, targeted grouting where necessary, drill, blast and excavation will be adopted to progress the MTS shaft from 83 m AOD to -157 m OD. Although the predominant strata within this construction depth is low permeability mudstone, grouting may be necessary if water bearing horizons are encountered in the Staithes Sandstone Formation, Cleveland Ironstone Formation or fractured sections of the Redcar Mudstone Formation. The objective of such grouting will be to limit the maximum permeability of the excavation annulus to $1x10^{-7}$ m/s and, as such, horizons of higher permeability will be treated to this level and the mudstone strata with a permeability below this value will remain ungrouted.

- Following completion of the Phase 4a VSM shaft sinking, shaft lining and injection of the cementitious grout seal around the base of that hydrostatic liner to 86.8 m AOD, the Phase 11 works will commence with construction of the top of the drained liner.

- Probe drilling will then be undertaken at approximately 40 m intervals to confirm groundwater inflows within the staged drill and blast excavations below this level. Targeted grouting will only be undertaken where necessary to reduce cumulative inflows to less than 50 m^3/day.

- The shaft bench will then be drilled for installation of the explosives to form a 10.2 m diameter excavation, followed by blasting.

- Arisings will be excavated and hauled to the surface.

- Subject to the side stability of the exposed shaft rock face, ground support will be provided using rock bolts and wire mesh. The maximum supported unlined section will be between 6m to 8m.

3.2.2.2 Probe Drilling to Define Targeted Grouting Requirements

Only limited grouting will be required to control groundwater ingress through the sandstone units of the Cleveland Ironstone Formation and Staithes Sandstone, and localised fractured horizons in the Redcar Mudstone Formation. Probe drilling will be undertaken in 40 m sections in advance of excavation and grouting undertaken only, where necessary, to minimise water ingress.

3.2.2.3 Grouting Process

Where required, a single ring of 150 mm diameter holes will be installed to create a 2 m thick grout curtain across permeable / fractured zones to reduce the permeability of the excavation sidewall to less than $1x10^{-7}$ m/s. This grouting process will be undertaken in descending 5 m stages to mitigate water/grout loss and bore hole collapse. These stage lengths will be shortened if persistent water loss or no flush return conditions arise.

Standard, microfine cement, acrylate or polyurethane grouts will be used together with fresh water, superplasticizer and anti-washout additives.

The grout injection pressure will be determined by pressure testing and the maximum pressure adopted will not cause hydrofracturing. Following grouting, post-treatment permeability testing will be undertaken for each stage.

Water used in drilling will be cleaned to remove silt to enable re-use. Recirculated water that doesn't meet the requirements of the grouting contractor it will be tankered off-site for disposal.

3.2.2.4 Blasting and Excavation

A grid pattern of holes will be drilled by rotary water flush techniques across the floor of the shaft excavation. The water used will be recirculated and wastewater tankered off-site for disposal.

To minimise the potential for spillage and loss of unspent explosives, cartridge emulsion explosives will be used comprising an aqueous solution of ammonium nitrate and other oxidising agents within an oil phase comprising waxes, emulsifier and oil (long chain C_{20} – C_{50} hydrocarbons comprising primarily saturated aliphatics). The blast design requires

approximately 500 kg of explosives per bench blast, which will generate approximately 300 m^3 of rock. Blast management quality control procedures are implemented to minimise the occurrence of mis-fire and unspent explosives to less than 0.5% per blast. As such, only trace concentrations of ammonia, nitrate and hydrocarbons from unspent explosives will be present in the blast arisings generated.

Due to the blast operation, fractured rock is expected to extend approximately 0.5 m behind the excavation surface.

Following blasting, the arisings including formation/construction waters will be mechanically excavated into a muck bucket, brought to the surface and placed in the material bunker to enable free drainage and assessment of its geotechnical condition. Wastewater drained from the rock fill will be collected for treatment in the NDWTP. The hydraulically operated mechanical excavators used in the shaft excavation will use a biodegradable lubricant comprising synthetic organic esters. As such, minor leakage of these oils from the excavation plant may introduce trace concentrations of long chain fatty acids and synthesized organic alcohols onto the blast rock arisings.

Materials determined acceptable for placement as a Class 4 Landscape Fill will be transported for either direct placement in Bund F in accordance with the Environmental Permit EPR/MB3399VR (Ref. 17) or to the Materials Handling Area to be mixed with dry material to achieve a geotechnically acceptable landscape fill. The water from the materials Handling Area will be collected in the attenuation tank in the southeast corner, regulated by a penstock valve to control and enable cut off prior to discharge to the perimeter swale. Monitoring of the water quality will be undertaken to confirm its suitability for discharge direct to the perimeter swale or either treatment at the NDWTP prior to discharge to surface waters under a discharge consent or tankered off site, as detailed in the Surface water drainage Scheme (Ref. 16).

3.2.3 Lining

Below the Phase 4a hydrostatic liner, the Phase 11 works will commence with construction of the permanent drained reinforced concrete liner will be constructed from top down to the base of the MTS shaft (-146.2 m OD), as illustrated in Arup Drawing 40-ARI-WS-1300-CI-18-40001. The liner pours will not exceed 2 m in height with the excavated bench <1 m below the last poured curb ring and the maximum supported unlined section limited to 6 m to 8 m.

Drain holes through the liner wall will enable free drainage of groundwater from the annulus of blast fractured rock behind the excavated shaft wall, as illustrated in Arup Drawing 40-ARI-WS-1313-CI-56-51309. Such water will be collected at the shaft excavation bench level during construction. Post shaft lining and during cavern construction water collecting in the base of the shaft will be pumped to surface from a sump.

3.3 Groundwater Management Measures

During shaft construction, sump pumping will be undertaken to manage water that infiltrates through the drained liner and flowing behind the liner within the fractured blast. Design calculations have determined that temporary groundwater management during shaft construction will be required to accommodate between 10 to 80 m^3/day of groundwater inflow to the shaft excavation. Groundwater inflow will be pumped to the surface from a sump where

collection and storage will be managed by either offsite disposal or through a non-domestic waste water treatment system.

An observational monitoring approach of groundwater inflows and pumping will be adopted throughout the excavation works including evaluation of:-

- Groundwater levels within the Ravenscar Formation.
- Groundwater ingress from exposed rock face during excavation.
- Impacts of rock breaking on groundwater ingress.

3.4 Construction Programme

The construction programme for the Phase 11 works is expected to be around 5 months from September 2019 to February 2020.

4 MINESITE HYDROGEOLOGICAL CONDITIONS

The stratigraphic units that will be encountered within the depth of the Phase 11 shaft construction works extend from the top of the Whitby Mudstone Formation to the Calcareous Shale unit of the Redcar Mudstone Formation, as illustrated in FWS Drawing 1433DevOD 406 Appendix 1. Detailed descriptions of the geology, geotechnical properties and hydrogeological conditions across these strata are presented in the Hydrogeological Baseline Report (Ref. 1) and a geological plan illustrating the Phase 11 works is presented in FWS Drawing 1433DevOD 407 Appendix 1. For the purpose of this report, a summary of the aquifer units, the interpreted groundwater surface, design permeability characteristics and water quality conditions within the depth profile of the proposed shaft construction works are provided in Table 2. The Ravenscar aquifer units highlighted in green are sealed off by the hydrostatic liner constructed as part of the Phase 4a works. Shaft sinking through the underlying low permeable Lias strata highlighted in blue will be undertaken using a drained liner construction.

In terms of aquifer status, the Whitby Mudstone is classified as “Unproductive strata” and forms a regionally important aquiclude. This provides a significant vertical barrier between groundwater in the overlying Secondary A Ravenscar Group aquifers and isolated waters in the underlying low permeable argillaceous sandstones, siltstones and mudstones of the Cleveland Ironstone and Staithes Sandstone strata, classified regionally as Secondary A Aquifers, and the Redcar Mudstone Formation Secondary B Aquifer.

The chemical quality of the groundwaters in the Ravenscar Group aquifers characterise as freshwater of good quality. Due to the non-aquifer characteristics of the Whitby Mudstone, Cleveland Ironstone, Staithes Sandstone and the Redcar Mudstone Formation, groundwater samples have not been recoverable from these strata. Based on the rock chemistry however, should groundwater be encountered within fissures in this stratum, this would be expected to be slightly alkaline with slightly elevated concentrations of sulphates.

Table 2 – MTS Shaft Aquifer Conditions

			MTS Shaft
Platform Level		m AOD	200.8
Shaft Excavation Diameter		m	10
Base of VSM Lined Shaft		m AOD	80.8
Base of Drill and Blast Shaft		m AOD	-146.2
Moor Grit Member (Sealed off)	**Top & Base Level of Aquifer**	m AOD	~199.0 to 190.9
	Inferred Groundwater Surface (Winter, Mean levels)	m AOD	Winter 195 to 196.8, average 195.9 (BH515)
	Aquifer Design Permeability	m/s	Most Likely 1.3 x10^{-5} m/s
	Water Quality		Good
Scarborough Formation (Sealed off)	**Top and Base Level of Upper Aquitard Unit**	m AOD	190.9 to 189.9
	Upper Aquitard Design Permeability	m AOD	Most Likely 4.0 x 10^{-6} m/s
	Elevation of Mid-Section Permeable Aquifer	m AOD	189.9 to 187.9
	Inferred Groundwater Surface	m AOD	190.2 to 193.6 (BH515)
	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	187.9 to ~186
	Lower Aquitard Design Permeability	m/s	Most Likely K_h 2 x 10^{-6} m/s, K_v 1 x 10^{-8} m/s
Cloughton Formation	**Top & Base Level of Upper Aquifer**	m AOD	186 to ~160
	Inferred Groundwater Surface	m AOD	~183.3 to ~192.4
	Aquifer Design Permeability	m/s	Most Likely K_v 1 x 10^{-4} m/s
	Water Quality		Good
	Top & Base Level of Lower Aquitard	m AOD	~160 to ~146
	Aquitard Design Permeability	m/s	Most Likely K_h 2 x 10^{-6} m/s, K_v 1 x 10^{-8} m/s
Eller Beck Formation	**Top & Base Level of Formation**	m AOD	146.0 to 142
	Inferred Groundwater Surface	m AOD	157.3
	Water Quality		Good
	Aquitard Design Permeability	m/s	1 x 10^{-7} m/s
Saltwick Formation	**Top & Base Level of Formation**	m AOD	~142 to ~96
	Inferred Groundwater Surface	m AOD	~135.7 to ~142
	Aquifer Design Permeability	m/s	Most Likely K_h 2 x 10^{-5} m/s
	Water Quality		Good
	Aquitard Design Permeability	m/s	5.7 x 10^{-7} m/s
Dogger Formation	**Top & Base Level of Upper Aquifer**	m AOD	96.1 to 92.4
	Inferred Groundwater Surface	m AOD	Assumed 138.8
	Water Quality		Good
	Aquifer Design Permeability	m/s	K_h 2.3 x 10^{-8} m/s
Whitby Mudstone	**Top & Base Level of Formation**	m AOD	92.4 to 16.2
	Inferred Groundwater Surface	m AOD	86 m AOD
	Water Quality		Expected slightly sulphatic
	Aquiclude Design Permeability	m/s	1 x 10^{-8} m/s (Kh:kv 100:1)
Cleveland Ironstone Formation	**Top & Base Level of Formation**	m AOD	16.2 to -11.3
	Inferred Groundwater Surface	m AOD	86 m AOD
	Water Quality		Expected slightly sulphatic
	Aquiclude Design Permeability	m/s	1 x 10^{-8} m/s to 1 x 10^{-7} m/s (Kh:Kv 100:1 to 25:1)
Staithes Sandstone	**Top & Base Level of Formation**	m AOD	-11.3 to -44
	Inferred Groundwater Surface	m AOD	111 m AOD
	Water Quality		Expected slightly sulphatic
	Aquiclude Design Permeability	m/s	1 x 10^{-8} m/s to 1 x 10^{-7} m/s (Kh:Kv 100:1 to 25:1)
Redcar Mudstone Formation – **Banded Ironstone and Pyritous Shale**	**Top & Base Level of Formation**	m AOD	-44 to -122.7
	Inferred Groundwater Surface	m AOD	68 m AOD
	Water Quality		Expected slightly sulphatic
	Aquiclude Design Permeability	m/s	1 x 10^{-8} m/s to 1 x 10^{-7} m/s (Kh:Kv 100:1 to 25:1)
Redcar Mudstone Formation – **Siliceous Shale**	**Top & Base Level of Formation**	m AOD	-122.7 to -181
	Inferred Groundwater Surface	m AOD	68 m AOD
	Water Quality		Expected slightly sulphatic
	Aquiclude Design Permeability	m/s	1 x 10^{-8} m/s to 1 x 10^{-7} m/s (Kh:Kv 100:1 to 25:1)
Redcar Mudstone Formation – **Calcareous Shale**	**Top & Base Level of Formation**	m AOD	-181 to -292
	Inferred Groundwater Surface	m AOD	68 m AOD
	Water Quality		Expected slightly sulphatic
	Aquiclude Design Permeability	m/s	1 x 10^{-8} m/s to 1 x 10^{-7} m/s (Kh:Kv 100:1 to 25:1)

5 RECEPTORS

The hydrogeological receptors and the ecological habitats on Ugglebarnby Moor that may be impacted upon by the Works are shown in Drawings 1433DevOD408 and 1433DevOD407 Appendix 1 and summarised in Table 3.

Table 3 – Receptors

Type	Receptor	Sensitivity
Sensitive Aquifers	Moor Grit Member (Secondary A Aquifer)	Medium
	Scarborough Formation (Secondary A Aquifer)	Medium
	Cloughton Formation (Secondary A Aquifer)	Medium
	Saltwick Formation (Secondary A Aquifer)	Medium
	Whitby Mudstone (Unproductive Strata)	Very Low
	Cleveland Ironstone (Secondary A Aquifer)	Very Low
	Staithes Sandstone (Secondary A Aquifer)	Very Low
	Redcar Mudstone (Secondary B Aquifer)	Very Low
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 (the shallow valley feature)*	High (Low)*
	Sneaton Low Moor Dry Heath Area	Low
Surface Waters	Sneaton Thorpe Beck	Low
	Little Beck	Medium

Note: *Recent ecological surveys (Ref. 18) have confirmed that there are no hydrogeologically supported ecosystems within this moorland area adjacent to the minesite and that this study has now reclassified an area of flora previously designated to be a Spring Flush habitat to be a soligenous habitat within the shallow valley feature. As a precautionary measure, until discussed further, this receptor will be classified as of High sensitivity.

6 QUALITATIVE HYDROGEOLOGICAL RISK ASSESSMENT

6.1 Conceptual Model

The upper section of the MTS shaft installed as part of the Phase 4a works penetrated 12 m into the Whitby Mudstone (92.4 to 80.8 m AOD), as illustrated in Drawing No. 1433DevOD406. As such, the drill and blast lining operations to extend the shaft below 80.8 m AOD will be 12 m below the overlying sensitive Secondary A aquifers and therefore isolated from these fresh waters by the undrained hydrostatic liner that seals the Phase 4a shaft into the upper section of the Whitby Mudstone aquiclude. Drill and blast shaft construction, including grouting where necessary, from 83 m AOD to the base of the shaft at -157 m OD in the Siliceous Shales will be confined within the low permeable argillaceous units within which only localised more permeable horizons are anticipated associated with thin interbeds of silty sandstone and fractured horizons. Although allowance has been made in the shaft design for a regional

phreatic surface in the Whitby Mudstone, Cleveland Ironstone and Staithes Sandstone at around 111 to 86 m AOD and in the Redcar Mudstone at around 68 m AOD, due to the very low vertical and horizontal permeabilities of these strata, water flows into the excavation and drained liner on completion will be very low.

Due to the blasting construction methodology, a fractured annulus (~0.5 m wide) is expected to form in the rock around the excavation face. As such, although only low flows are anticipated from the argillaceous strata during construction, the cumulative flow will pass into the excavation from both the exposed rock face and from drainage holes in the completed sections of shaft liner above. On completion of lining to the base of the MTS shaft, groundwater entering the drained shaft will either evaporate or flow to the base of the shaft to be sump pumped to surface.

Within the minesite area, there are no hydrogeologically-supported terrestrial ecosystems or groundwater abstractions Drawing 1433Dev408 Appendix 1. The shallow Secondary A Aquifers beneath the minesite area are determined as being of local importance providing base flow to surface waters, in particular to Sneaton Thorpe Beck. These shallow aquifers are isolated from Phase 11 drill and blast shaft construction by the shaft liner and the upper section of the Whitby Mudstone aquiclude Drawing 1433Dev406 Appendix 1.

Offsite, in the southern area of Ugglebarnby Moor (Drawing 1433DevOD408 Appendix 1), is flora in the shallow valley feature that is fed by surface runoff and infiltration held in the superficial deposits, with only a minor and intermittent contribution to the general soil dampness by groundwater within the Moor Grit aquifer. The dry heath ecosystems in the northern and southern areas of Ugglebarnby Moor, and on Sneaton Low Moor and the wet heath ecosystems in the central area of Ugglebarnby Moor, are not hydrogeologically supported by shallow groundwaters in the bedrock aquifers. There are four groundwater abstractions in close proximity to the minesite; one from a well drilled into the Cloughton Formation at Sneaton Low Moor Caravan Park, and three from spring issues; one associated with Thornhill Farm (and the adjacent property) Moorside Farm Spring (MF2), Soulsgrave Farm Spring (SF2) and Newton House Farm Spring (NHF1). There are three spring discharges that have been determined to contribute low and intermittent volumes to surface water flows to the west of Ugglebarnby Moor (SP01, SP02 and SP03), and two to the north of the Woodsmith Mine (SP04 and KHF).

6.2 Groundwater Effects

The physical and chemical groundwater effects that may arise as a result of the Phase 11 Works are summarised in Tables 4 and 5:-

6.2.1 Physical Effects

Table 4 – Physical Effects

Effect	Discussion	Magnitude of Effect at Source
Drill and Blast Shaft Excavation		
During shaft excavation, groundwater ingress could occur through fractured and arenaceous rock. Such ingress could inundate the excavation and inhibit construction operations.	Down the MTS shaft profile, strata to be excavated is predominantly argillaceous with a permeability of less than $1x10^{-7}$ m/s. Only local argillaceous sandstone beds and horizons of more fractured strata are expected, where permeabilities may be greater the $1x10^{-7}$ m/s. Prior to excavation through both the ungrouted and grouted sections, probe drilling will be undertaken to confirm only low water flows are to be managed by sump pumping from the open excavation. Where high flows are encountered additional targeted grouting will be undertaken, as necessary, to limit inflows.	Very Low Magnitude of Effect at Source.
Grouting and installation of a drained liner may cause a temporary and permanent alteration of groundwater flow paths and levels in the Ravenscar Formation and in the underlying Whitby Mudstone, Cleveland Ironstone, Staithes Sandstone and Redcar Mudstone.	Within the design, a nominal 50 mm annulus of fractured rock with high permeability may develop down the shaft excavation profile. Inflow estimates indicate that by the base of the Whitby Mudstone cumulative groundwater ingress to the shaft could reach 10 m^3/day, the Cleveland Ironstone 15 m^3/day, the Staithes Sandstone 35 m^3/day and the Redcar Mudstone by 80 m^3/day. Sump pumping will be undertaken to maintain the excavation dry during all drilling, excavation and shaft lining operations. Installation of the hydrostatic liner to 86.8 m AOD with a grout seal at its base in the Whitby Mudstone aquiclude will isolate hydraulic continuity between the Ravenscar Formation and the underlying drill and blast construction activities. Due to the predominantly argillaceous nature and low permeability of the strata down the excavation profile, localised grouting and drainage of permeable horizons around the shaft will cause only a local change in groundwater flow paths and drainage in the Whitby Mudstone, Cleveland Ironstone, Staithes Sandstone and Redcar Mudstone and will cause no under drainage of groundwater from the overlying Ravenscar aquifers.	Very Low Magnitude of Effect at Source
Construction of Bund F using Drill and Blast Arisings		
Construction of the localised area of landscape Bund F will cause local reduction to recharge into the near surface aquifers.	Due to the small surface area the section of Bund F to be constructed during the Phase 11 works, the proposed earthworks will have no significant physical impact on recharge into the Scarborough and Cloughton aquifers with no significant physical impact to the groundwater levels.	Very Low Magnitude of Effect at Source.
Construction of Bund F above a low permeable cohesive subgrade could cause perched waters to develop within the fill over the long term, which could impact on the slope stability of the mound.	To prevent build-up of a perched water table within the landscape fill, a basal drainage layer has been incorporated into the design that will drain water within the fill to discharge into the perimeter surface water drainage system.	Low Magnitude of Effect at Source.

Effect	Discussion	Magnitude of Effect at Source
Groundwater ingress into the base of Bund F could occur along the spring line at the base of the Scarborough aquifer, which could raise porewater pressure at the base of the fill and present a future slope stability risk to the bund construction.	A basal drainage system will be constructed along the spring line to collect spring water issues and discharge this water to the perimeter surface water drainage system.	Low Magnitude of Effect at Source

6.2.2 Chemical Effects

Table 5 – Chemical Effects

Effect	Discussion	Magnitude of Effect at Source
	Drill and Blast Shaft Excavation	
Groundwater pollution from grouting operations using cementitious grouts.	Grouting operations will involve non-hazardous, non ecotoxic inert cement based grout, bentonite, plasticizers and retarders only. Potential Contaminants of Concern (CoC) from these works include; total dissolved solids, turbidity, alkaline pH and elevated conductivity. Implementation of environmental control measures during grouting operations through the CEMP (Ref. 16) will limit the possibility of water flush loss, grout loss or spillage occurring. Published data on the geochemical impacts of cementitious materials on groundwater composition indicates that, whilst short-term variations in pH, alkalinity, Ca and K concentrations can occur local to the cementitious injection zone, once the concrete cures it is inert to groundwater leaching, with only marginally elevated levels of K, Ca and alkalinity remaining adjacent to the hardened concrete. As these ions are quickly buffered along the groundwater flow path, cementitious grouts present no significant risk of pollution contamination to groundwater quality.	Very Low Magnitude of Effect at Source
Groundwater pollution from targeted grouting operations using acrylate and polyurethane based grouts.	Grouting operations may utilise acrylate and polyurethane grouts, together with potassium ferricyanide and sodium persulphate catalysts. Potential CoC from these works include; total dissolved solids, turbidity, low concentrations of Ferrate(3-) hexacyano-tripotassium, sodium persulphate, sodium bicarbonate, dibutyl phthalate and potassium chloride, which can present a risk of harm to fish and invertebrates. Implementing environmental control measures during grouting operations through the CEMP (Ref. 16) will limit the possibility of water flush loss, grout loss or spillage occurring and provide procedures to ensure that they are contained and dealt with quickly. As such, the magnitude of effect at source will be very low.	Very Low Magnitude of Effect at Source

Effect	Discussion	Magnitude of Effect at Source
Temporary and localised groundwater pollution around the shaft excavation may arise from leakage / spillage of; hydraulic lubricants from the excavation plant, recirculation of recycled flush water during drilling to install cartridge explosives, and from leaching of residual unspent explosives.	Rapidly biodegradable synthetic hydraulic oils are to be utilised by the excavation plant. These synthetic organic alcohols present a low pollution hazard to groundwater. A structured maintenance and monitoring regime will be adopted through the CEMP (Ref.16) for the construction operations and plant, to ensure that there are no significant leaks or spillages of hydraulic fluids or lubricants that may enter the excavation or become adhered to the excavation arisings. To maintain a high water quality to the drill flush waters, these will be passed through a recycling unit to remove particulates prior to recirculation. All construction waste waters taken from the shaft excavation will either be disposed of offsite or treated within an onsite water treatment facility, prior to discharge to Sneaton Thorpe Beck under an Environmental Permit surface water discharge consent.	Low Magnitude of Effect at Source.
Construction of Bund F using Drill and Blast Arisings		
Arisings from the drill and blasting operations may contain residual concentrations of unspent explosive residues and hydraulic oils from the excavation plant. Such contamination in the rock arisings could leach from the fill placed in Bund F and impact on ground and surface water quality.	The cartridge packed emulsion explosives contain mineral oil, paraffin and wax. Potential CoC from these explosives include ammonia, nitrates, chloride and C20 through C50 saturated aliphatic hydrocarbons. Quality control procedures will be implemented during the detonation and blast management process to limit the proportion of unspent explosive residues to less than 0.5% by weight of blast arisings generated. The blast arisings placed in Bund F will therefore contain very low concentrations of ammonia, nitrate, chloride and long chain aliphatic hydrocarbons. Leaching of these CoC from the low proportion of unspent explosives in the rock fill is determined to present a low pollution hazard to groundwater and to surface water quality both during construction and in the longer term. Rapidly biodegradable synthetic hydraulic oils are to be utilised by the excavation plant. These synthetic organic alcohols present a low pollution hazard to ground and surface water. Water within the blasting arisings will free drain in the material bunker and taken to the non-domestic waste water plant for treatment. Wet material placed on the Material Handling Area will free drain into the hold tank prior to discharge via a penstock valve to the surface water perimeter drain. A structured maintenance and monitoring regime will be adopted through the CEMP (Ref.16) for the construction operations to ensure that only low concentrations are present in the rock fill arisings placed in Bund F. Leaching of these CoC from the rock fill is determined to present a low pollution hazard to groundwater and to surface water quality both during construction and in the longer term.	Low Magnitude of Effect at Source.

Effect	Discussion	Magnitude of Effect at Source
During construction, surface water runoff from exposed rock arisings in Bund F will discharge to the perimeter drain within the main surface water drainage system that outflows to Sneaton Thorpe Beck. This discharge could therefore impact on water quality in Sneaton Thorpe Beck.	Chemical characterisation of the extractive materials to be generated from the MTS shaft excavation (Ref. 12) has determined that water in contact with these materials could leach low concentrations of sulphate, chloride, heavy metals and PAH. Engineering measures have been incorporated into the design of the bund to restrict the open area for filling and restoration to a maximum of 2 ha. This will minimise the surface area exposed to infiltration and will limit the volume and flow rate of construction surface waters off the rock fill that enter the main surface water drainage system. These construction surface waters will discharge to a perimeter swale flowing to an attenuation pond, where it will mix with clean surface water run-off from the shaft platform and completed bund areas prior to discharge to Sneaton Thorpe Beck at the northern tributary (Discharge OF8 Drawing (Arup Drawing 40-ARI-WS-71-CI-DR-3019). Although construction surface water runoff in contact with the rock fill materials could therefore affect the chemical quality of surface water drainage, engineering measures have been adopted to minimise the effects of waters discharging into Sneaton Thorpe Beck.	High Magnitude of Effect at Source
Precipitation onto operational and unrestored areas in Bund F that permeates through the rock fill will be collected by the basal drainage system. This will discharge to the perimeter drain within the main surface water drainage system that outflows to Sneaton Thorpe Beck. The basal drainage discharge could therefore impact on water quality in Sneaton Thorpe Beck.	Chemical characterisation of the extractive materials to be generated from the MTS shaft excavation (Ref. 12) has determined that water in contact with these materials could leach low concentrations of sulphate, chloride, heavy metals and PAH. To minimise the quantity and flow of water from the basal drainage system, engineering measures have been incorporated into the design of the bund to include compaction of the rock materials to limit permeation of water through the rock fill and thereby restrict the generation of leachates. In addition, to limit the surface area open to infiltration, the operational and unrestored area is to be restricted to a maximum open area of 2 ha at any one time. To minimise water ingress into the rock fill after restoration, the bund will have a cover layer including a land drainage system. To maximise the dilution and attenuation of waters discharging from the basal drainage system into the surface water drainage system, it will first discharge to the perimeter swale and then flow to an attenuation pond where it will mix with clean surface water run-off from the shaft platform and completed bund area prior to discharge to Sneaton Thorpe Beck. Although discharge for the basal drainage system could therefore affect the chemical quality of surface water drainage, engineering measures have been adopted to minimise the effects of waters discharging into Sneaton Thorpe Beck.	High Magnitude of Effect at Source

Effect	Discussion	Magnitude of Effect at Source
Permeation of precipitation through the rockfill in Bund F, during construction and post restoration conditions, will mobilise soluble contamination from the fill that could permeate through the base of the bund into the underlying Moor Grit and Scarborough Aquifers.	Chemical characterisation of the extractive materials to be generated from the MTS shaft excavation (Ref. 12) has determined that water in contact with these materials could leach low concentrations of sulphate, chloride, heavy metals and PAH. To minimise the quantity and flow of water through the rock fill during construction, the bund materials are to be compacted to reduce their porosity and permeability. In addition, to limit the surface area open to infiltration, the operational and unrestored area is to be limited to a maximum open area of 2 ha at any one time. To minimise water ingress into the rock fill after restoration, the bund will have a cover layer including a land drainage system. To minimise permeation of water through the base of the bund into the Glacial Till and below formation level, a basal drainage system will be constructed. This drainage will limit the head of water that can build up above the prepared formation. By implementing these control measures only negligible infiltration will occur through the base of the bund that could impact on groundwater quality in the underlying Moor Grit and Scarborough aquifers.	Moderate Magnitude of Effect at Source

6.3 Hydrogeological Risk Assessment

A qualitative hydrogeological risk assessment has been carried out in accordance with the methodology presented in Appendix 2 to evaluate the potential physical and chemical impacts of the Works on the site specific hydrogeological receptors, detailed in Section 5, and the results are presented in Appendix 3.2 and discussed in Section 6.4.

For the assessment of pollution impacts of the CoC within the rock arisings to be placed in Bund F, a quantitative hydrogeological risk assessment has been undertaken as part of the Landscaped Bund design submitted for the approved Environmental Permit EPR/MB3399VR and the results (Ref. 12) are discussed in Section 6.4.

Evaluation of the Likelihood of Occurrence of an impact has been undertaken by consideration of the Proximity and Connectivity between an activity and the receptor. Appendix 3.1, evaluates the proximity of each activity to each receptor taking account of both horizontal and vertical proximity. To determine the Likelihood of Occurrence of an impact on a receptor, the physical and chemical impacts have been evaluated by consideration of the activity with the worst case proximity (i.e. highest values detailed in Appendix 3.2) to each receptor in conjunction with the worst case connectivity (between an activity and the receptor). The magnitude of the worst case proximity adopted for each receptor and the Likelihood of Occurrence determined are presented in Appendix 3.2.

The Magnitude of Effect at the Receptor has been evaluated by consideration of the qualitative assessment of the Magnitude of Effect at Source, as presented in Section 6.2 and the Likelihood of Occurrence as presented in Appendix 3.2.

Assessment of the Significance of Impact of the physical and chemical effects on the specific hydrogeological receptors have been evaluated by consideration of the Magnitude of Effect at

Receptor and the Receptor Sensitivity and the results are presented in Appendix 3.2 and evaluated in Section 6.4.

6.4 Results of the Hydrogeological Risk Assessment

For all hydrogeological receptors, including Moorside Farm Spring, Soulsgrave Farm Spring and the habitat within the shallow valley feature, as well as the surface waters and springs, the qualitative risk assessment demonstrates that the Phase 11 Works will have a Negligible Physical and Chemical Impact. As detailed in the Section 73 Hydrogeological Risk Assessment (Ref. 11), this development will have a negligible cumulative long term hydrogeological impact on all hydrogeological receptors.

For Bund F, groundwater and surface water contaminant transport modelling has been undertaken to simulate the potential pollution impacts of percolating waters through the rock fill (Ref. 13). That modelling submitted for the approved Environmental Permit EPR/MB3399VR demonstrated that the water ingress and permeation through the rock fill presents a negligible pollution risk to groundwaters in the underlying Moor Grit and Scarborough aquifers and to surface water quality in Sneaton Thorpe Beck.

7 CONSIDERATION OF MITIGATION MEASURES

This risk assessment has demonstrated that no additional measures are required as part of the Works to mitigate hydrogeological impacts on the environment. To ensure that the hydrogeological conditions are managed effectively during these construction works, testing and monitoring procedures for specific construction activities are detailed in the Groundwater Management Scheme (Refs. 19) and will be carried out in accordance with the requirements of the Environmental Permit (Permit Number EPR/MB3399VR). As part of these works provision has been made for the installation of ground water drainage measures under Bund F within the basal drainage blanket.

As part of this assessment, consideration has been given as to whether the recharge trench to the west of Bund C and groundwater drainage beneath Bund E are necessary mitigation measures to be initiated as part of these Phase 11 Works. Taking account of the previously submitted quantitative modelling outputs and field monitoring data (Ref. 20), this hydrogeological risk assessment has demonstrated that these measures are not warranted at this stage of the construction process.

C MILLER
ASSOCIATE DIRECTOR

R IZATT-LOWRY
DIRECTOR

8 REFERENCES

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4 FWS Consultants Ltd, 2017 Hydrogeological Risk Assessment for the Phase 4 Works at Woodsmith Mine, North Yorkshire, North Yorkshire (1433OR205).

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6 FWS Consultants Ltd, 2018 Hydrogeological Risk Assessment for the Phase 5 Works at Woodsmith Mine, North Yorkshire, North Yorkshire (1433OR378).

7 FWS Consultants Ltd, 2018 Hydrogeological Risk Assessment for the Phase 6 Works at Woodsmith Mine, North Yorkshire, North Yorkshire (1433OR396).

8 FWS Consultants Ltd, 2018 Hydrogeological Risk Assessment for the Phase 7 Works at Woodsmith Mine, North Yorkshire, North Yorkshire (1433OR398).

9 FWS Consultants Ltd, 2018 Hydrogeological Risk Assessment for the Phase 8 Works at Woodsmith Mine, North Yorkshire, North Yorkshire (1433OR407).

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14 FWS Consultants Ltd, 2019 Construction and Operation Phase Ground and Surface Water Monitoring Scheme for the Phase 11 Works at Woodsmith Mine, North Yorkshire (1433OR444).

15 Sirius Woodsmith Mine Phase 11 Construction Method Statement Document No. 40-SMP-WS-7100-PA-MS- (Ref. 15).

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18 Environmental Permit EPR/MB3399VR 10/05/2019 York Potash Ltd. Runoff and Basal Drainage of Bunds at Woodsmith Mine.

19 PAC Ltd, Ugglebarnby Moor Vegetation Survey (2018). 40-PCA-WS-8300-EN-SV-00001/V3.

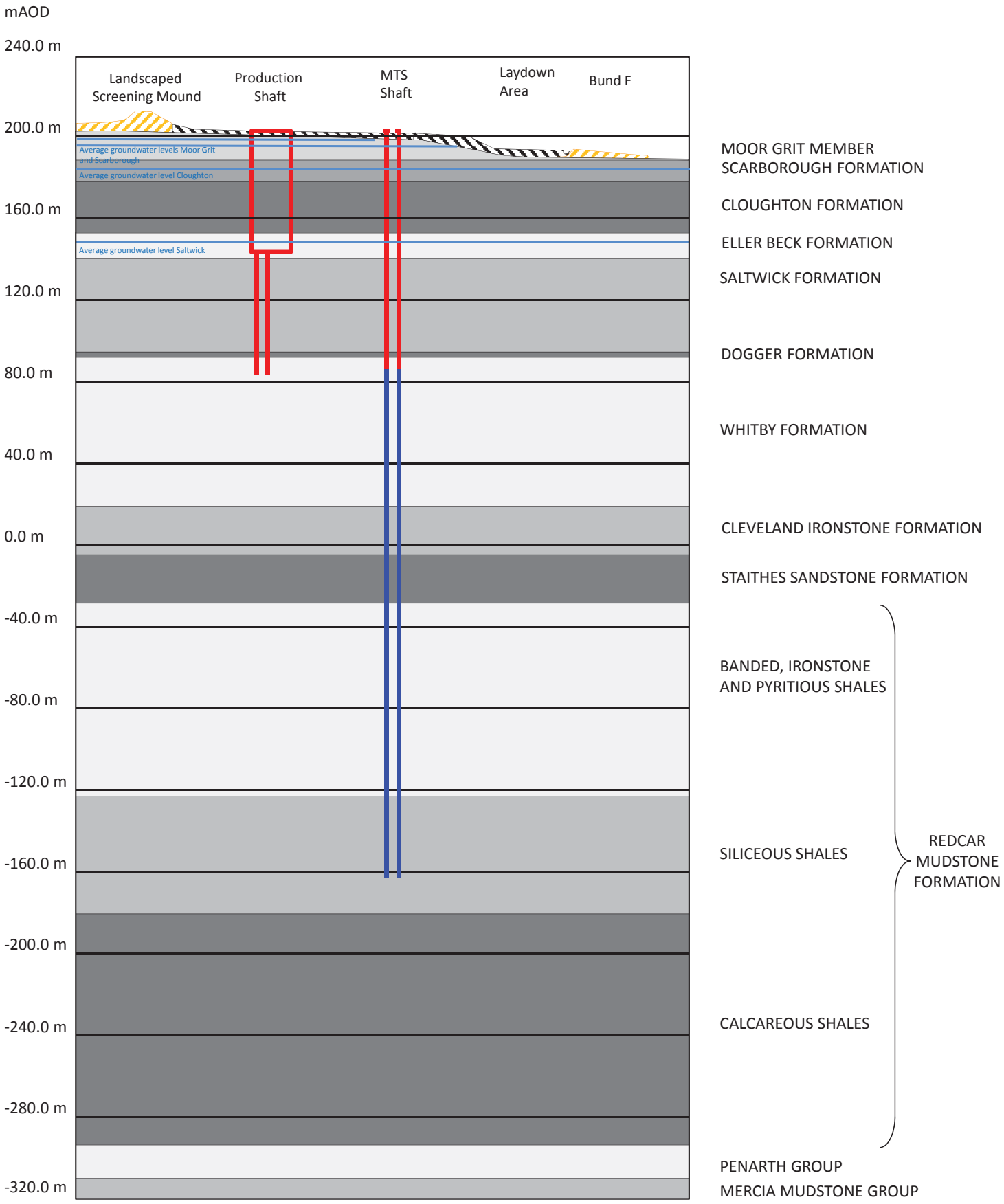
20 FWS Consultants Ltd, 2019 Ground Management Scheme for the Phase 11 Works at Woodsmith Mine, North Yorkshire (1433OR443).

APPENDIX 1

DRAWINGS

1 DRAWINGS

1433DevOD 406	HYDROGEOLOGICAL SCHEMATIC SECTION THROUGH PHASE 11 WORKS AT SERVICE AND MTS SHAFTS
1433DevOD 407	GEOLOGICAL PLAN FOR PHASE 11 WORKS
1433DevOD 408	PHASE 11 HYDROGEOLOGICAL RECEPTORS AND ECOLOGICALLY SENSITIVE HABITATS ON UGGLEBARNBY MOOR



NOTES / KEY

- HYDROSTATIC SHAFT LINER
- DRAINED SHAFT LINER
- LANDSCAPED SCREENING MOUND
- GRANULAR PLATFORM CONSTRUCTION AND LAYDOWN AREA

DRAWING TITLE

PHASE 11 - SCHEMATIC CROSS SECTION THROUGH BUND F, PRODUCTION SHAFT AND MTS SHAFT

PROJECT TITLE

NORTH YORKSHIRE POLYHALITE PROJECT

CLIENT
SIRIUS MINERALS PLC

STATUS	PROJECT NUMBER
FINAL	1433Dev
DRAWN BY	DATE
CM	June 2019
SCALE	DRG. No.
AS SHOWN	1433DevOD406

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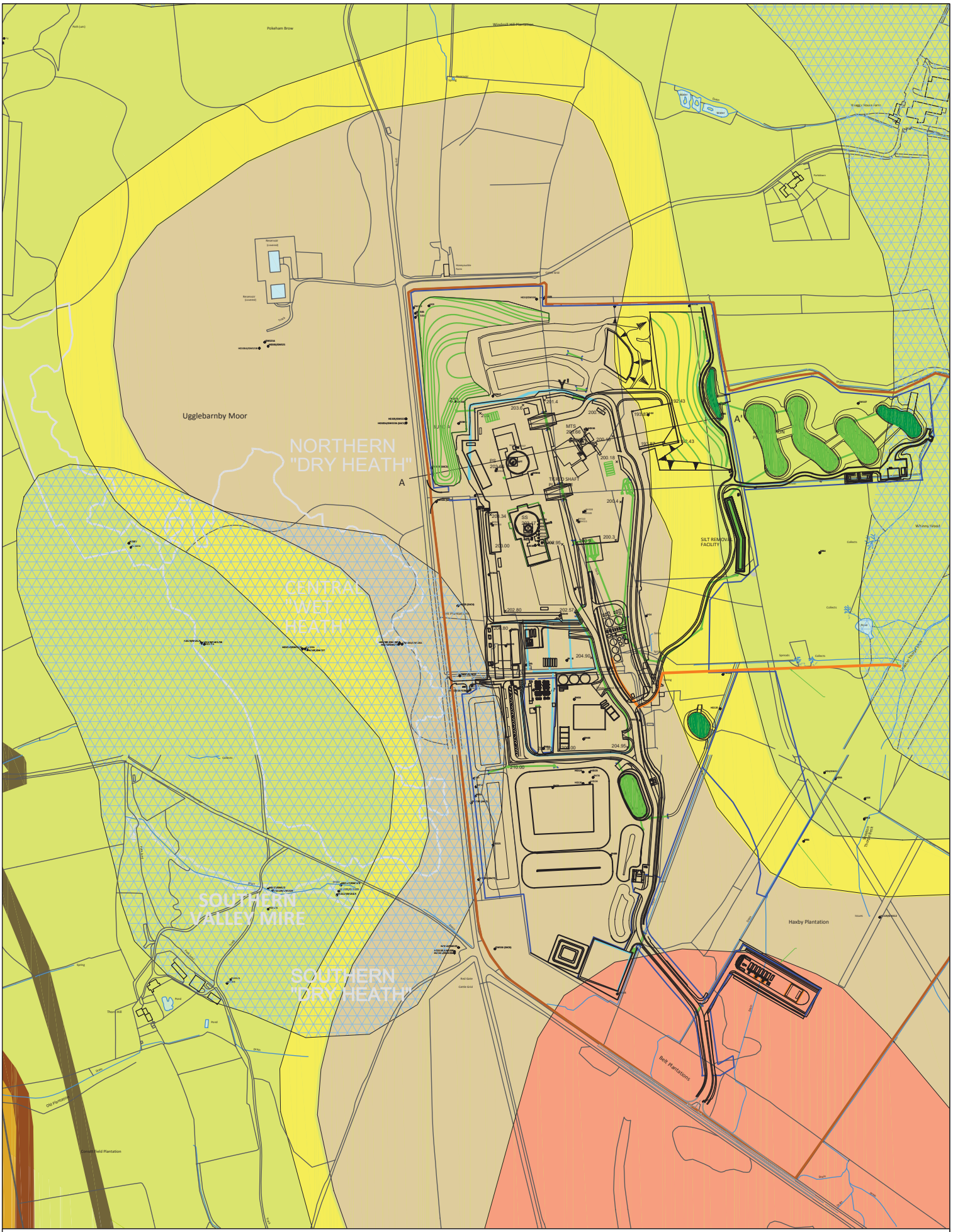

NOTES / KEY

SITE OWNERSHIP BOUNDARY
NYM SAC
SURFACE WATER
BOREHOLES GCBH01
HYDROGEOLOGICAL RECPTORS MF2
LINE OF CROSS SECTION
CROSS SECTION A-A' DRAWING 1433DevOD406

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

DRAWING TITLE
GEOLOGICAL MAP AND LINE OF CROSS SECTIONS

PROJECT TITLE
NORTH YORKSHIRE POLYHALITE PROJECT

CLIENT
SIRIUS MINERALS PLC

STATUS
FINAL

PROJECT NUMBER
1433Dev

DRAWN BY
CM

DATE
JULY 2019

SCALE
1:5,000@A3/1:2,500@A1

DRG. No.
1433DevOD407

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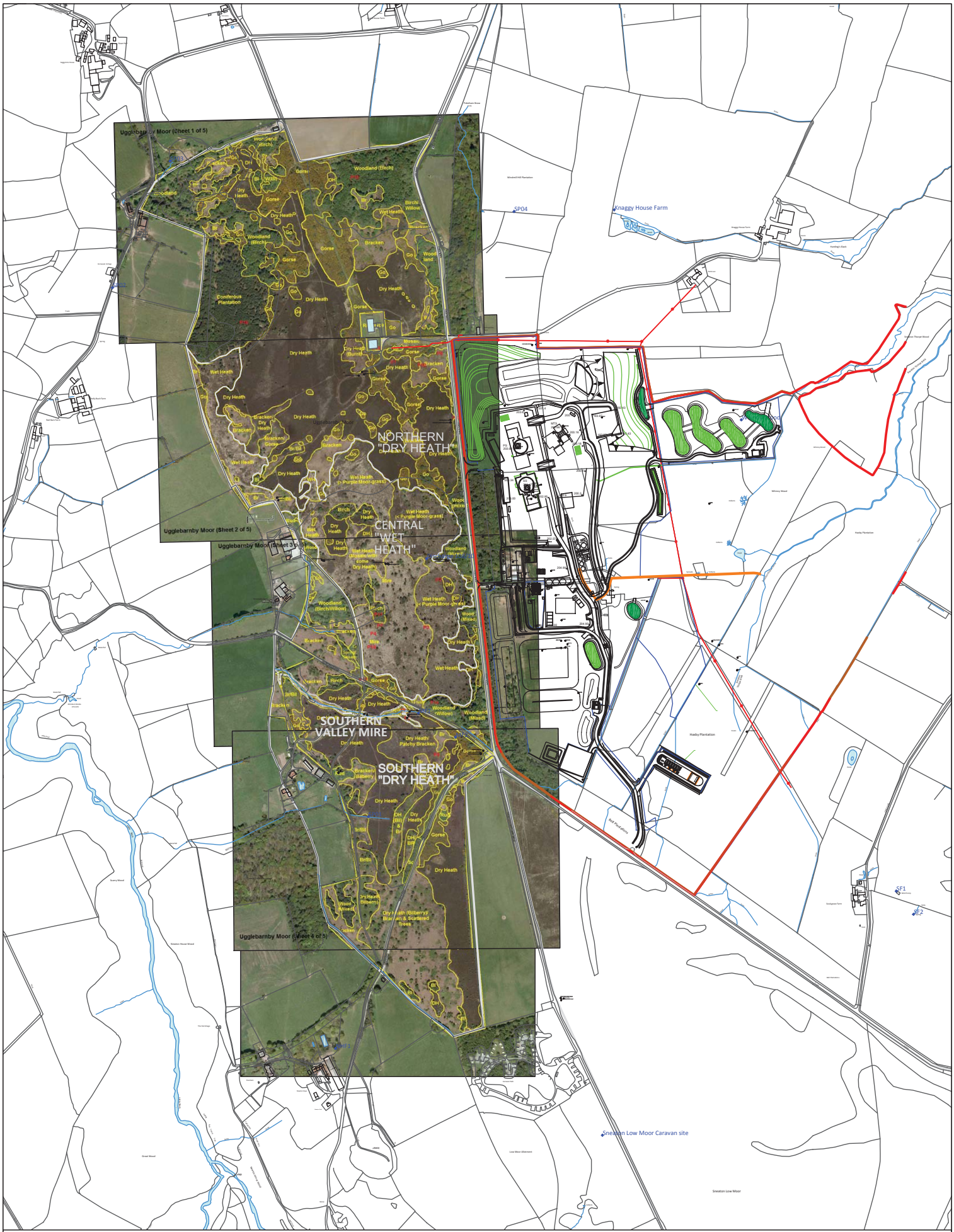

NOTES / KEY

NYM SAC

SURFACE WATER

BOREHOLES GCBH01

HYDROGEOLOGICAL RECEPTORS MF2

DRAWING TITLE
HYDROGEOLOGICAL RECEPTORS AND ECOLOGICALLY SENSITIVE HABITATS ON UGGLEBARNBY MOOR - PHASE 11

CLIENT
SIRIUS MINERALS PLC

STATUS
FINAL

PROJECT NUMBER
1433Dev

PROJECT TITLE
NORTH YORKSHIRE POLYHALITE PROJECT

DRAWN BY
CM

DATE
JULY 2019

SCALE
1:5,000@A3/1:2,500@A1

DRG. No.
1433DevOD408

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APPENDIX 2

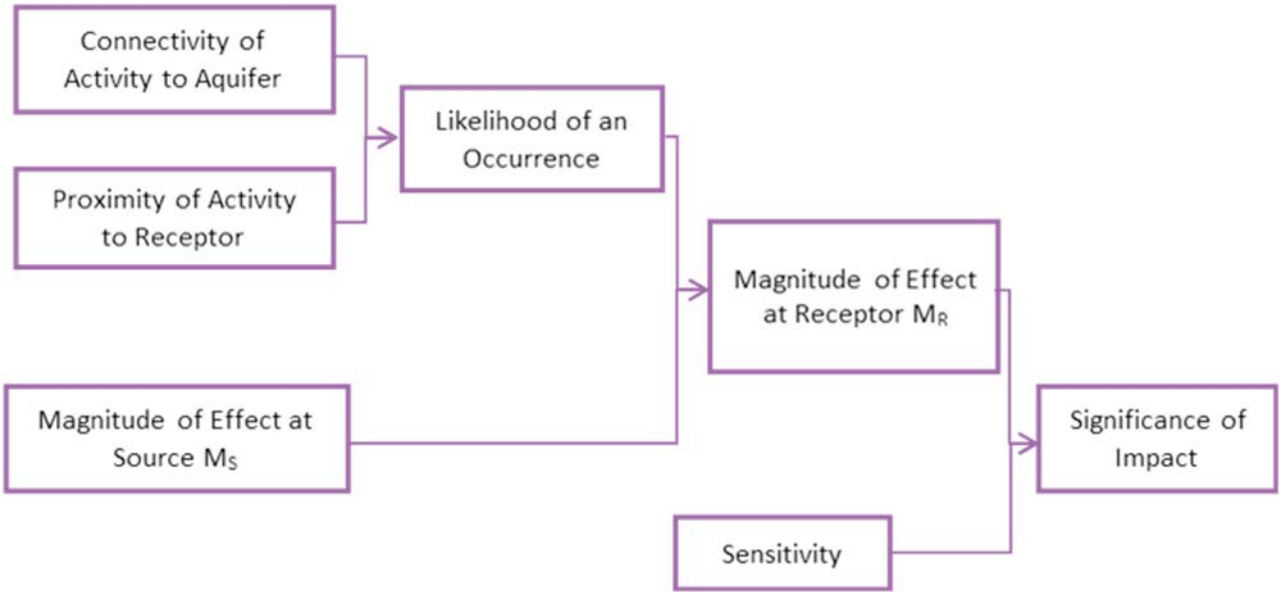
RISK ASSESSMENT METHODOLOGY

APPENDIX 2

1 RISK ASSESSMENT METHODOLOGY

The revised qualitative hydrogeological risk assessment presented in this report evaluates the "Significance of Impact" of the Phase 11 Works on hydrogeologically sensitive receptors, and follows a source-pathway-receptor approach to meet regulatory requirements.

In order to evaluate the physical and chemical hydrogeological impacts, the following criteria, and the linkages between them, have been considered:-



Two criteria have been used to assess the "Likelihood" of an effect propagating through the hydrogeological system to a receptor. These are the Connectivity and Proximity of an activity to a receptor. Therefore, the closer and more directly connected an activity is to a receptor, the more likely it is that a pathway will exist between an activity and that receptor.

The Magnitude of Effect at Source (MS) has been considered in terms of the worst-case physical and chemical changes to baseline conditions that might occur.

Combining the Likelihood of an Occurrence with the Magnitude of Effect at Source provides a qualitative evaluation for the Magnitude of Effect at Receptor (MR), which is the effect that a particular activity will have on a specific receptor.

The Magnitude of Effect at Receptor is then combined with the Sensitivity of the Receptor to provide an estimate of the Significance of Impact.

Five categories are used to describe the Connectivity, the Proximity, the Likelihood of an Occurrence, the Magnitude of Effect at Source (MS), the Magnitude of Effect at Receptor (MR); and the Sensitivity of a Receptor:-

- Very High
- High
- Medium
- Low

- Very Low

Four categories are then used to describe the overall "Significance of Impact":-

- Major
- Moderate
- Minor
- Negligible

The results of the revised qualitative assessment are given in risk matrices presented in Appendix 3 that identify which of the five categories above apply to specific activities and receptors during the Phase 11 Works and, from this, it has been assessed which of the four categories of "Significance of Impact" they belong.

The following sections provide descriptions and definitions for each of these categories as they apply to each of the components of the qualitative risk assessment.

1.1 Likelihood of Occurrence

The Likelihood of Occurrence of a physical or chemical effect is evaluated by combining Connectivity and Proximity of an activity to a receptor, as detailed below.

Likelihood	**Connectivity between Activity and Receptor**					
		Very Low	**Low**	**Medium**	**High**	**Very High**
Receptor Proximity to Activity	**Very Low**	Very Low	Low	Low	Medium	Medium
	Low	Low	Low	Medium	Medium	High
	Medium	Low	Medium	Medium	High	High
	High	Medium	Medium	High	High	Very High
	Very High	Medium	High	High	Very High	Very High

1.1.1 Connectivity

Very High Connectivity	Activity and receptor occur in the same aquifer unit, with a direct or known pathway between them. For chemical impacts, the receptor is also down hydraulic gradient from the activity and on the same flow path (determined as being a line of flow between the source and the receptor that is perpendicular to groundwater contours).
High Connectivity	Activity and receptor occur in the same aquifer unit but the pathway is indirect as a result of the presence of a very thin (<1 m) or discontinuous aquitard. For chemical impacts, the receptor is down hydraulic gradient from the activity and is slightly oblique to the flow path.
Medium Connectivity	Activity and receptor occur in adjacent aquifer units that are in hydraulic continuity but are separated by a thin (>1 m), fractured or leaky aquitard. For chemical impacts the receptor is down hydraulic gradient from the activity and is strongly oblique to a flow path.
Low Connectivity	Activity and receptor are in adjacent aquifer units with no or very limited hydraulic continuity between them due to the presence of a natural or man-made aquitard. For chemical impacts the receptor is down hydraulic gradient from the activity and is on a different flow path.
Very Low Connectivity	There is no hydraulic continuity between the activity and the receptor due to the presence of a laterally and vertically continuous, or multiple thin (>1 m) aquitard units, an aquiclude unit or an engineered barrier unit. For chemical impacts, the receptor is up hydraulic gradient from the activity.

1.1.2 Proximity

In accordance with Environment Agency guidance on groundwater protection (Ref. 12), the minimum permitted distance for the proximity of a potentially polluting activity to a water abstraction is 50 m (equivalent to Source Protection Zone I). As such, for the purpose of this qualitative risk assessment a distance of <50 m has been used to define the condition of Very High Proximity. By consideration of Environment Agency guidance for the minimum distance of 250 m to a Source Protection Zone II this distance has been used to define the condition of High Proximity. Moderate and a Low Proximity limits have been set equally spaced from the 250 m zone, at 500 and 750 m respectively, and a Very Low Proximity has been defined as >750 m. The following absolute values have, therefore, been used to evaluate the Proximity of an activity to a receptor.

Very high proximity	< 50 m
High proximity	51 – 250 m
Medium proximity	251 – 500 m
Low proximity	501 – 750 m
Very low proximity	>750 m

A multi-layered aquifer system also requires consideration of vertical proximity. In order to take this into account, the proximity between aquifers moving down vertically through a sequence is reduced by one category for each aquifer to be consistent with the concept of connectivity.

1.2 Magnitude of Effect at Source (M_S)

The Magnitude of Effect at Source of a physical or chemical impact is categorised, as detailed below:-

Very High Magnitude of Effect at Source	A very high degree of physical change is a change in groundwater level that is >150% of the regional natural annual groundwater level variation for an aquifer, or >150% of the natural variation in flowrate from a spring. A very high degree of chemical change is a change of >150% of the natural baseline chemical quality variation that could cause a risk of harm or give rise to a pollution risk.
High Magnitude of Effect at Source	A high degree of physical change is a change in groundwater level that is between 100 and 150% of the regional natural annual groundwater level variation for an aquifer, or between 100 and 150% of the natural variation in flowrate from a spring. A high degree of chemical change is a change of between 100 and 150% of the natural baseline chemical quality variation that could cause a risk of harm or give rise to a pollution risk.
Medium Magnitude of Effect at Source	A moderate degree of physical change is a change in groundwater level that is between 50 and 100% of the local natural annual groundwater level variation for an aquifer, or between 50 and 100% of the natural variation in flowrate from a spring. A high degree of chemical change is a local change of between 50 and 100% of the natural baseline chemical quality variation that could cause a risk of harm or give rise to a pollution risk.
Low Magnitude of Effect at Source	A low degree of physical change is a change in groundwater level that is between 20 and 50% of the local natural annual groundwater level variation for an aquifer, or between 20 and 50% of the natural variation in flowrate from a spring. A low degree of chemical change is a local change of between 20 and 50% of the natural baseline chemical quality variation.
Very Low Magnitude of Effect at Source.	A very low degree of physical change is a change in groundwater level that is <20% of the local natural annual groundwater level variation for an aquifer, or <20% of the flow from a spring. A very low degree of chemical change is a local change of <20% of the local natural baseline chemical variation.

1.3 Magnitude of Effect at Receptor (MR)

The Magnitude of Effect at any Receptor is estimated by combining the Magnitude of Effect at Source and the Likelihood of a hydrogeological "effect" occurring, as detailed in the matrix below:-

Magnitude of Effect at the Receptor		**Likelihood**				
		Very Low	**Low**	**Medium**	**High**	**Very High**
Magnitude of Effect at Source	**Very Low**	Very Low	Very Low	Very Low	Very Low	Very Low
	Low	Very Low	Very Low	Low	Low	Low
	Medium	Very Low	Low	Low	Medium	Medium
	High	Very Low	Low	Medium	High	High
	Very High	Very Low	Low	Medium	High	Very High

A description of the five categories of hydrogeological "Magnitude of Effect at the Receptor" that have been used in this report are presented below:-

Magnitude of Effect at Receptor	**Description**
Very High	Loss of resource and/or integrity of the resource; severe damage to key characteristics or features and permanent/ irreplaceable change is certain to occur.
High	Loss of resource, but not affecting the overall integrity of the resource; partial loss of or damage to key characteristics or features and permanent/irreplaceable change is likely to occur.
Medium	Minor loss of, or alteration to, key characteristics of a resource; measurable change in attributes, quality or vulnerability. Long term, though reversible change, is likely to occur.
Low	Very minor loss of, or alteration to, key characteristics of a resource; noticeable change in attributes, quality or vulnerability. Short to medium term, though reversible, change could possibly occur.
Very Low	Temporary or intermittent very minor loss of, or alteration to, key characteristics of a resource; noticeable change in attributes, quality or vulnerability. Short to medium term change is unlikely to occur, and when does is likely to be intermittent and reversible.

1.4 Receptor Sensitivity

The sensitivity of groundwater receptors in the qualitative risk assessment 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 the table overleaf:-

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. • Designated SAC, SPA, or Ramsar site with fauna or flora that are intermittently but not primarily hydrogeologically supported from groundwaters. • SSSI, NNR with fauna or flora that are hydrogeologically supported from groundwaters within 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.
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.

1.5 Significance of Impact

The significance of the impact that changes will have on a hydrogeological receptor is assessed by comparing the Magnitude of Effect at Receptor with the receptor Sensitivity. This is assessed using the following matrix.

Receptor Sensitivity	Magnitude Of Effect At Receptor				
	Very Low	**Low**	**Medium**	**High**	**Very High**
Very Low	Negligible	Negligible	Negligible	Negligible	Minor
Low	Negligible	Negligible	Minor	Minor	Minor
Medium	Negligible	Minor	Minor	Moderate	Moderate
High	Negligible	Minor	Moderate	Moderate	Major
Very High	Negligible	Minor	Moderate	Major	Major

The four categories assigned to the Significance of Impact above relate to a Major, Moderate, Minor or negligible (as identified below) against which the necessity to implement mitigation measures is evaluated.

Significance of Impact	Description	Necessity Of Mitigation Measures
Major	Major risk of unacceptable change to a sensitive hydrogeological receptor.	Mitigation measures required.
Moderate	Moderate risk with measurable change to a sensitive hydrogeological receptor.	Mitigation measures required.
Minor	Minor risk with local minor change to a sensitive hydrogeological receptor.	Mitigation measures may be required.
Negligible	No risk and no discernible change to a sensitive hydrogeological receptor.	No mitigation measures required.

APPENDIX 3

QUALITATIVE RISK ASSESSMENT

APPENDIX 3.1

EVALUATION OF PROXIMITY OF RECEPTOR TO THE PHYSICAL AND CHEMICAL EFFECTS OF CONSTRUCTION WORKS ASSOCIATED WITH SPECIFIC PHASE 11 WORKS ACTIVITIES

Receptor and Associated Geology		() = overlying	Phase 11 Works Activities and Associated Geology
			MTS Shaft
			Moor Grit, Scarborough, Cloughton, Saltwick, Dogger, Whitby Mudstone, Cleveland Ironstone, Staithes Sandstone, Redcar Mudstone
Ugglebarnby Moor Northern Dry Heath Area	**Dry Heath Ecology**	Distance (m) Horizontal Proximity **Calculated Proximity**	245 High **High**
Ugglebarnby Moor Central Wet Heath Area	**Wetland Ecology**	Distance (m) Horizontal Proximity **Calculated Proximity**	315 Medium **Medium**
Ugglebarnby Moor Southern Dry Heath Area	**Dry Heath Ecology**	Distance (m) Horizontal Proximity **Calculated Proximity**	650 Low **Medium**
Ugglebarnby Moor Southern Spring Flush	**Wetland Ecology**	Distance (m) Horizontal Proximity **Calculated Proximity**	750 Low **Low**
Sneaton Low Moor Dry Heath Area	**Dry Heath Ecology**	Distance (m) Horizontal Proximity **Calculated Proximity**	820 Low **Low**
Sneaton Thorpe Beck	**Surface Water**	Distance (m) Horizontal Proximity **Calculated Proximity**	560 Low **Low**
Little Beck	**Surface Water**	Distance (m) Horizontal Proximity **Calculated Proximity**	1370 Very Low **Very Low**
Sneaton Low Moor Caravan Park Cloughton Fm	**Drinking Water**	Distance (m) Horizontal Proximity **Calculated Proximity**	1670 Very Low **Very Low**
MF2 Moor Grit	**Drinking Water**	Distance (m) Horizontal Proximity **Calculated Proximity**	760 Very Low **Very Low**
SF2 Scarborough Fm	**Drinking Water**	Distance (m) Horizontal Proximity **Calculated Proximity**	1350 Very Low **Very Low**
NHF Cloughton Fm	**Drinking Water**	Distance (m) Horizontal Proximity **Calculated Proximity**	1550 Very Low **Very Low**
SP01 Moor Grit	**Baseflow**	Distance (m) Horizontal Proximity **Calculated Proximity**	1020 Very Low **Very Low**
SP02, SP03 Cloughton Fm	**Baseflow**	Distance (m) Horizontal Proximity **Calculated Proximity**	1125 Very Low **Very Low**
SP04 Moor Grit	**Baseflow**	Distance (m) Horizontal Proximity **Calculated Proximity**	550 Low **Low**
DNS1 Moor Grit	**Baseflow**	Distance (m) Horizontal Proximity **Calculated Proximity**	330 Medium **Medium**
Knaggy House Farm Spring Scarborough Fm	**Baseflow**	Distance (m) Horizontal Proximity **Calculated Proximity**	550 Low **Low**
Moor Grit Secondary A Aquifer	**"Shallow aquifer/ Drinking water/ Baseflow"**	Distance (m) Horizontal Proximity **Calculated Proximity**	0 Very High **Very High**
Scarborough Fm Secondary A Aquifer	**"Shallow aquifer/ Drinking water/ Baseflow"**	Distance (m) Horizontal Proximity **Calculated Proximity**	0 Very High **Very High**
Cloughton Fm Secondary A Aquifer	**"Moderate depth aquifer/ Drinking water/ Baseflow"**	Distance (m) Horizontal Proximity **Calculated Proximity**	0 Very High **Very High**
Saltwick Fm Secondary A Aquifer	**Moderate depth aquifer**	Distance (m) Horizontal Proximity **Calculated Proximity**	0 Very High **Very High**
Whitby Mudstone Fm Unproductive Strata	**Deep depth aquiclude**	Distance (m) Horizontal Proximity **Calculated Proximity**	0 Very High **Very High**
Cleveland Ironstone Fm Secondary A Aquifer	**Deep depth aquifer unused**	Distance (m) Horizontal Proximity **Calculated Proximity**	0 Very High **Very High**
Staithes Sandstone Fm Secondary A Aquifer	**Deep depth aquifer unused**	Distance (m) Horizontal Proximity **Calculated Proximity**	0 Very High **Very High**
Redcar Mudstone Fm Secondary B Aquifer	**Deep depth aquiclude**	Distance (m) Horizontal Proximity **Calculated Proximity**	0 Very High **Very High**

Note: Calculated Proximity is determined from the Horizontal Proximity and the Vertical Proximity as detailed in Appendix 2.

APPENDIX 3.2 - Qualitative Hydrogeological Risk Assessment - Phase 11 Works

			Ugglebarnby Moor Northern Dry Heath Area	Ugglebarnby Moor Central Wet Heath Area	Ugglebarnby Moor Southern Dry Heath Area	Ugglebarnby Moor Southern Spring Flush Area	Sneaton Low Moor Dry Heath Area	Sneaton Thorpe Beck	Little Beck	Sneaton Low Moor Caravan Park	MF2	SF2	NHF
			Dry Heath Ecology	Wetland Ecology	Dry Heath Ecology	Wetland Ecology	Dry Heath Ecology	Surface Water	Surface Water	Drinking Water	Drinking Water	Drinking Water	Drinking Water
PHYSICAL IMPACTS	During shaft excavation, groundwater ingress could occur through fractured and arenaceous rock. Such ingress could inundate the excavation and inhibit construction operations.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	High	Medium	Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Medium	Low	Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Low**	**Low**	**Low**	**High**	**Low**	**Low**	**Medium**	**High**	**High**	**High**	**High**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Grouting and installation of a drained liner may cause a temporary and permanent alteration of groundwater flow paths and levels in the Ravenscar Formation and in the underlying Whitby Mudstone, Cleveland Ironstone, Staithes Sandstone and Redcar Mudstone.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	High	Medium	Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Medium	Low	Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Low**	**Low**	**Low**	**High**	**Low**	**Low**	**Medium**	**High**	**High**	**High**	**High**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Construction of the localised area of landscape Bund F will cause local reduction to recharge into the near surface aquifers.	Connectivity between Activity and Receptor	Low	Low	Low	Low	Low	Low	Low	Medium	High	High	Medium
		Receptor Proximity to Activity	Medium	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Medium	Low	Low	Low	Low	Low	Low	Low	Medium	Medium	Low
		Magnitude of Effect at Source	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Low**	**Low**	**Low**	**High**	**Low**	**Low**	**Medium**	**High**	**High**	**High**	**High**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Construction of Bund F above a low permeable cohesive subgrade could cause perched waters to develop within the fill over the long term, which could impact on the slope stability of the mound.	Connectivity between Activity and Receptor	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
		Receptor Proximity to Activity	Medium	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Medium	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
		Magnitude of Effect at Source	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
		Magnitude of Effect at Receptor	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Low**	**Low**	**Low**	**High**	**Low**	**Low**	**Medium**	**High**	**High**	**High**	**High**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Groundwater ingress into the base of Bund F could occur along the spring line at the base of the Scarborough aquifer, which could raise porewater pressure at the base of the fill and present a future slope stability risk to the bund construction.	Connectivity between Activity and Receptor	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
		Receptor Proximity to Activity	Medium	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Medium	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
		Magnitude of Effect at Source	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
		Magnitude of Effect at Receptor	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Low**	**Low**	**Low**	**High**	**Low**	**Low**	**Medium**	**High**	**High**	**High**	**High**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**

APPENDIX 3.2 - Qualitative Hydrogeological Risk Assessment - Phase 11 Works

			SP01	SP02, SP03	SP04	Knaggy House Farm Spring	Moor Grit Secondary A Aquifer	Scarborough Fm Secondary A Aquifer	Cloughton Fm Secondary A Aquifer	Saltwick Fm Secondary A Aquifer	Whitby Fm Unproductive Strata	Cleveland Ironstone Fm Secondary A Aquifer	Staithes Sandstone FM Secondary A Aquifer	Redcar Mudstone Fm Secondary B Aquifer
			Baseflow	Baseflow	Baseflow	Baseflow	Shallow aquifer/ Drinking water/ Baseflow	Shallow aquifer/ Drinking water/ Baseflow	Medium depth aquifer/ Drinking water/ Baseflow	Medium depth aquifer	Deep depth aquiclude	Deep depth aquifer/Unused	Deep depth aquifer/Unused	Deep depth aquiclude
PHYSICAL IMPACTS	During shaft excavation, groundwater ingress could occur through fractured and arenaceous rock. Such ingress could inundate the excavation and inhibit construction operations.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Medium	High	Very High	Very High	Very High	Very High
		Receptor Proximity to Activity	Very Low	Very Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very High	Very High	Very High	Very High
		Likelihood	Very Low	Very Low	Low	Low	Very Low	Very Low	Low	Medium	Very High	Very High	Very High	Very High
		Magnitude of Effect at Source	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Medium**	**Medium**	**Medium**	**Medium**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Grouting and installation of a drained liner may cause a temporary and permanent alteration of groundwater flow paths and levels in the Ravenscar Formation and in the underlying Whitby Mudstone, Cleveland Ironstone, Staithes Sandstone and Redcar Mudstone.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Medium	High	Very High	Very High	Very High	Very High
		Receptor Proximity to Activity	Very Low	Very Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very High	Very High	Very High	Very High
		Likelihood	Very Low	Very Low	Low	Low	Very Low	Very Low	Low	Medium	Very High	Very High	Very High	Very High
		Magnitude of Effect at Source	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Medium**	**Medium**	**Medium**	**Medium**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Construction of the localised area of landscape Bund F will cause local reduction to recharge into the near surface aquifers.	Connectivity between Activity and Receptor	High	Medium	High	Medium	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	Very Low	Very Low	Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Medium	Low	Medium	Medium	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Medium**	**Medium**	**Medium**	**Medium**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Construction of Bund F above a low permeable cohesive subgrade could cause perched waters to develop within the fill over the long term, which could impact on the slope stability of the mound.	Connectivity between Activity and Receptor	High	Medium	High	Medium	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	Very Low	Very Low	Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Medium	Low	Medium	Medium	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
		Magnitude of Effect at Receptor	**Low**	**Very Low**	**Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Medium**	**Medium**	**Medium**	**Medium**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Groundwater ingress into the base of Bund F could occur along the spring line at the base of the Scarborough aquifer, which could raise porewater pressure at the base of the fill and present a future slope stability risk to the bund construction.	Connectivity between Activity and Receptor	High	Medium	High	Medium	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	Very Low	Very Low	Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Medium	Low	Medium	Medium	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
		Magnitude of Effect at Receptor	**Low**	**Very Low**	**Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Medium**	**Medium**	**Medium**	**Medium**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**

APPENDIX 3.2 - Qualitative Hydrogeological Risk Assessment - Phase 11 Works

			Ugglebarnby Moor Northern Dry Heath Area	Ugglebarnby Moor Central Wet Heath Area	Ugglebarnby Moor Southern Dry Heath Area	Ugglebarnby Moor Southern Spring Flush Area	Sneaton Low Moor Dry Heath Area	Sneaton Thorpe Beck	Little Beck	Sneaton Low Moor Caravan Park	MF2	SF2	NHF
			Dry Heath Ecology	Wetland Ecology	Dry Heath Ecology	Wetland Ecology	Dry Heath Ecology	Surface Water	Surface Water	Drinking Water	Drinking Water	Drinking Water	Drinking Water
CHEMICAL IMPACTS	Groundwater pollution from grouting operations using cementitious grouts.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	Medium	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Low	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Low**	**Low**	**Low**	**High**	**Low**	**Low**	**Medium**	**High**	**High**	**High**	**High**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Groundwater pollution from targeted grouting operations using acrylate and polyurethane based grouts.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	Medium	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Low	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Low**	**Low**	**Low**	**High**	**Low**	**Low**	**Medium**	**High**	**High**	**High**	**High**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Temporary and localised groundwater pollution around the shaft excavation may arise from leakage / spillage of; hydraulic lubricants from the excavation plant, recirculation of recycled flush water during drilling to install cartridge explosives, and from leaching of residual unspent explosives.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	Medium	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Low	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Low**	**Low**	**Low**	**High**	**Low**	**Low**	**Medium**	**High**	**High**	**High**	**High**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Arisings from the drill and blasting operations may contain residual concentrations of unspent explosive residues and hydraulic oils from the excavation plant. Such contamination in the rock arisings could leach from the fill placed in Bund F and impact on ground and surface water quality.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	Medium	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Low	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Low**	**Low**	**Low**	**High**	**Low**	**Low**	**Medium**	**High**	**High**	**High**	**High**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	During construction, surface water runoff from exposed rock arisings in Bund F will discharge to the perimeter drain within the main surface water drainage system that outflows to Sneaton Thorpe Beck. This discharge could therefore impact on water quality in Sneaton Thorpe Beck.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	Medium	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Low	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	High	High	High	High	High	High	High	High	High	High	High
		Magnitude of Effect at Receptor	**Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Low**	**Low**	**Low**	**High**	**Low**	**Low**	**Medium**	**High**	**High**	**High**	**High**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Precipitation onto operational and unrestored areas in Bund F that permeates through the rock fill will be collected by the basal drainage system. This will discharge to the perimeter drain within the main surface water drainage system that outflows to Sneaton Thorpe Beck. The basal drainage discharge could therefore impact on water quality in Sneaton Thorpe Beck.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	Medium	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Low	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	High	High	High	High	High	High	High	High	High	High	High
		Magnitude of Effect at Receptor	**Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Low**	**Low**	**Low**	**High**	**Low**	**Low**	**Medium**	**High**	**High**	**High**	**High**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**

APPENDIX 3.2 - Qualitative Hydrogeological Risk Assessment - Phase 11 Works

			SP01	SP02, SP03	SP04	Knaggy House Farm Spring	Moor Grit Secondary A Aquifer	Scarborough Fm Secondary A Aquifer	Cloughton Fm Secondary A Aquifer	Saltwick Fm Secondary A Aquifer	Whitby Fm Unproductive Strata	Cleveland Ironstone Fm Secondary A Aquifer	Staithes Sandstone FM Secondary A Aquifer	Redcar Mudstone Fm Secondary B Aquifer
			Baseflow	Baseflow	Baseflow	Baseflow	Shallow aquifer/ Drinking water/ Baseflow	Shallow aquifer/ Drinking water/ Baseflow	Medium depth aquifer/ Drinking water/ Baseflow	Medium depth aquifer	Deep depth aquiclude	Deep depth aquifer/Unused	Deep depth aquifer/Unused	Deep depth aquiclude
CHEMICAL IMPACTS	Groundwater pollution from grouting operations using cementitious grouts.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very High	Very High	Very High	Very High
		Receptor Proximity to Activity	Very Low	Very Low	Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Very Low	Very Low	Low	Low	Low	Very Low	Very Low	Very Low	Medium	Medium	Medium	Medium
		Magnitude of Effect at Source	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Medium**	**Medium**	**Medium**	**Medium**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Groundwater pollution from targeted grouting operations using acrylate and polyurethane based grouts.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very High	Very High	Very High	Very High
		Receptor Proximity to Activity	Very Low	Very Low	Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Very Low	Very Low	Low	Low	Low	Very Low	Very Low	Very Low	Medium	Medium	Medium	Medium
		Magnitude of Effect at Source	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Medium**	**Medium**	**Medium**	**Medium**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Temporary and localised groundwater pollution around the shaft excavation may arise from leakage / spillage of; hydraulic lubricants from the excavation plant, recirculation of recycled flush water during drilling to install cartridge explosives, and from leaching of residual unspent explosives.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very High	Very High	Very High	Very High
		Receptor Proximity to Activity	Very Low	Very Low	Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Very Low	Very Low	Low	Low	Low	Very Low	Very Low	Very Low	Medium	Medium	Medium	Medium
		Magnitude of Effect at Source	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Low**	**Low**	**Low**	**Low**
		Sensitivity (Value of Resource)	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Medium**	**Medium**	**Medium**	**Medium**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Arisings from the drill and blasting operations may contain residual concentrations of unspent explosive residues and hydraulic oils from the excavation plant. Such contamination in the rock arisings could leach from the fill placed in Bund F and impact on ground and surface water quality.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	Very Low	Very Low	Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Very Low	Very Low	Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Medium**	**Medium**	**Medium**	**Medium**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	During construction, surface water runoff from exposed rock arisings in Bund F will discharge to the perimeter drain within the main surface water drainage system that outflows to Sneaton Thorpe Beck. This discharge could therefore impact on water quality in Sneaton Thorpe Beck.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	Very Low	Very Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Very Low	Very Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	High	High	High	High	High	High	High	High	High	High	High	High
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Medium**	**Medium**	**Medium**	**Medium**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Precipitation onto operational and unrestored areas in Bund F that permeates through the rock fill will be collected by the basal drainage system. This will discharge to the perimeter drain within the main surface water drainage system that outflows to Sneaton Thorpe Beck. The basal drainage discharge could therefore impact on water quality in Sneaton Thorpe Beck.	Connectivity between Activity and Receptor	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Receptor Proximity to Activity	Very Low	Very Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Likelihood	Very Low	Very Low	Low	Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low
		Magnitude of Effect at Source	High	High	High	High	High	High	High	High	High	High	High	High
		Magnitude of Effect at Receptor	**Very Low**	**Very Low**	**Low**	**Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Sensitivity (Value of Resource)	**Very Low**	**Very Low**	**Very Low**	**Very Low**	**Medium**	**Medium**	**Medium**	**Medium**	**Very Low**	**Very Low**	**Very Low**	**Very Low**
		Significance of Impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**Negligible**

NYMNPA

29/07/2019

SIRIUS MINERALS PLC

Project Title / Facility Name:

North Yorkshire Polyhalite Project

Document Title:

PHASE 11 NOISE AND VIBRATION MANAGEMENT PLAN

Document Review Status

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REPORT

Phase 11 - Woodsmith Mine Noise and Vibration Management Plan

Woodsmith Mine Phase 11 - NVMP

Client: Sirius Minerals plc

Reference: 40-RHD-WS-70-EN-PL-0040 Rev 0

Status: 01/Final

Date: 26 July 2019

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1 INTRODUCTION

1.1 Purpose of this Report

1.1.1 In 2014 a planning application (reference NYM/2014/0676/MEIA) was submitted to North York Moors National Park Authority (NYMNPA) for permission to develop a polyhalite mine and underground Mineral Transport System (MTS). Planning permission was subsequently granted in 2015 subject to conditions, as varied in February 2018 by NYM/2017/0505/MEIA.

1.1.2 This document has been prepared on behalf of Sirius Minerals plc (Sirius Minerals) and details the requirements with respect to noise and vibration management for the Phase 11 Works (see Paragraph 1.1.4 below) at Woodsmith Mine. This document is required to partially satisfy the requirements of Conditions 18 and 29 of the NYMNPA planning permission. These planning conditions are detailed in **Table 1-1** and **Table 1-2**.

Table 1-1: Condition NYMNPA 18 Noise and Vibration Management Plan

NYMNPA 18	Compliance with Condition NYMNPA-18
Prior to the commencement of each Phase of Construction at Dove's Nest Farm or Lady Cross Plantation, a Noise and Vibration Management Plan (NVMP) for the control, mitigation and monitoring of noise and vibration for both construction and operational phases at the two sites shall be submitted to and approved in writing by the MPA in consultation with the SBC EHO. The scheme shall set out the following:	This document addresses Phase 11 Works at Woodsmith Mine. Works at Lady Cross Plantation are deferred and are therefore not addressed in this Plan.
Noise-sensitive receptors for which predictions shall be made and at which the noise and vibration limits shall apply and which shall include recreational receptors.	Section 3.1
Predicted noise levels at the noise-sensitive receptors from noise and vibration generated at the DNF and LCP sites for the key construction phases during the forthcoming year including any periods in which the higher daytime limit of 70 dB L_{Aeq} shall apply (permitted 56 days for temporary works to create noise-reducing bunds and/or barriers as per Conditions 20 and 22).	Section 3, and Appendix C
The best practicable means which will be used to control noise and vibration levels on site including such measures proposed in the Environmental Statement (September 2014 as updated by the Supplementary Environmental Statement dated February 2015) and the Supplementary Environmental Statement dated July 2017 (updated by further information dated October and November 2017) as relevant. Such measures shall include, but are not limited to: the use of the quietest available plant, equipment and techniques; the regular maintenance and inspection of such plant and equipment; the use of cladding, attenuators and barriers to reduce noise levels from noisy plant and operations; the specification of appropriate reversing alarms to minimise annoyance; and, measures to reduce vibration and air overpressure during blasting.	Section 5
Details of the noise and vibration monitoring system to be installed around the DNF and LCP sites to continuously log noise levels during construction and operation. The system shall include at least six noise monitors installed around the boundary of the Dove's Nest site and at least four monitors at key residential receptors near the Dove's Nest site and at least four noise monitors around the Lady Cross Plantation Site and at least three monitors at key residential receptors near the Lady Cross Plantation site.	Section 4

NYMNPA 18	Compliance with Condition NYMNPA-18
The precise number and location of noise monitors shall be set out in the NVMP. The developer shall use reasonable endeavours to obtain access to the residential receptor properties for the installation of noise monitors and only if access cannot be obtained the number or location of noise monitors may be reduced. The MPA and the SBC EHO and/or their advisers shall be granted access to inspect the noise and vibration data whenever required, records of the data should be kept for a reasonable period and these records should be accessible by the public.	Section 3, Section 4 and Figure B.1
Details of the procedure to be followed in the event that the noise predictions detailed in the NVMP or the noise limits detailed in conditions 20 to 23 are exceeded. Such procedures shall require the investigation of the reasons for the breach of the limits and the cessation of the activity causing the breach until such a time as additional mitigation can be provided.	Section 5.4
Details of how the residents will be informed and consulted about the site operations and progress, particularly in regard to blasting and especially noisy operations including details of complaints logging and management procedures and a 24-hour telephone incident hotline. Details of the procedure for investigating complaints and informing complainants of the results of such investigations and of any actions resulting from them.	Section 5.4 and Scheme for the Prior Notification of Blasting (40-SMP-WS-1000-PA-PL-00001)
The NVMP shall be adhered to at all times unless agreed previously in writing by the MPA.	
The NVMP shall be updated and agreed whenever appropriate to reflect changes in the programme during construction and operation and at intervals not less than 6 months after the initial start on site and thereafter annually.	Section 1

Table 1-2: Condition NYMNPA 29 Scheme for the Monitoring of Blasting Vibration

NYMNPA 29	Compliance with Condition NYMNPA-29
Prior to the commencement of any blasting operations associated with shaft sinking or chamber construction, a scheme for the monitoring of blasting vibration within 1 kilometre of the site shall be submitted to the MPA for approval. Blast monitoring shall take place in accordance with the approved scheme and the results forwarded to the MPA on a quarterly basis until the completion of those blasting operations.	Section 1 and Section 5

1.1.3 This NVMP relates to the Phase 11 Works at Woodsmith Mine and does not include any activities at Lady Cross Plantation, as these works have been deferred. The NYMNPA has confirmed that it supports this approach.

1.1.4 Phase 4, 4a, 5, 6, 7 and 9 activities will continue past the start date of Phase 11. Phase 8 activities are subject to a separate NVMP (40-RHD-WS-70-EN-PL-0034) and are not considered in this document. Phase 8 included the construction of permanent buildings, which is subject to separate noise limits as specified in condition NYMNPA-20.

1.1.5 This NVMP therefore supersedes all previous NVMPs (with the exception of that for Phase 8) upon the commencement of Phase 11 and considers processes and controls with respect to all activities on site throughout Phase 11. Specific activities required for Phase 11 comprise the following:

- Development of landscape mitigation screening;
- Tree clearance within the Haxby Plantation;
- Sinking of the MTS shaft via drill and blast method;
- Operation of the Galloway;
- Creation of a materials handling area;
- Installation of external silencer to the dust collector of the Service Shaft building; and
- Installation of batteries.

Planning Conditions

1.1.6 In addition to Condition NYMNPA 18, two further conditions NYMNPA 20 and NYMNPA 21 establish noise limits relating to the Woodsmith Mine site (see **Section 2.2**). Planning condition detail is provided in **Table 1-3** and **Table 1-4**.

Table 1-3: Condition NYMNPA 20 Noise Limits during Construction - Daytime

NYMNPA 20	Compliance with Condition NYMNPA-20
Day-time (07.00 hrs to 19.00 hrs) noise levels $L_{Aeq,1hr}$ from mine construction at the Dove's Nest site, excluding blasting operations, shall not exceed 55 dB $L_{Aeq,1hr}$ and for short-term, construction activities solely relating to the demolition of existing buildings and erection of new structures excluding earth mound and bunds shall not exceed 65dB $L_{Aeq,1hr.}$ An upper limit of 70 dB $L_{Aeq,1hr}$ for the purposes of temporary noisy operations to provide noise-reducing earth bunds and / or barriers may be permitted for up to 56 days in any calendar year provided such temporary operations are specified and agreed in the NVMP described in Condition 18. Each calendar day when the higher temporary noise level is exceeded shall be counted as one day. Noise levels shall be measured in accordance with BS 4142:2014 and the limits apply at the curtilage boundary of residential properties and at the following recreational receptors: Falling Foss tea room, Lound House Camp/Caravan site, Sneaton Foss Lane Caravan site and at any location on the Wainwright Coast to Coast walk footpath as illustrated in drawing number PB1110-P2-7-002 which is Figure 7.2 of Part 2 of the York Potash Project Mine, MTS and MHF Environmental Statement dated September 2014.	Section 3, and Appendix C

Table 1-4: Condition NYMNPA 21 Noise Limits during Construction - Nighttime

NYMNPA 21	Compliance with Condition NYMNPA-21
Evening (19.00 hrs to 22.00 hrs) and night-time (22.00 to 07.00 hrs) noise levels $L_{Aeq,1hr}$ from mine construction at the Dove's Nest site, excluding blasting operations, shall not exceed 42 dB $L_{Aeq,1hr}$ Noise levels shall be measured in accordance with BS 4142: 2014 and the limits apply at the curtilage boundary of residential properties and at the following recreational receptors: Lound House Camp/Caravan site and Sneaton Caravan site.	Section 3, and Appendix C

1.1.7 Conditions NYMNPA 24, 27, 28 and 29 relate to vibration arising from blasting activities during underground chamber construction or shaft sinking activities. Planning condition detail is provided in **Table 1-5** to **Table 1-7**.

Table 1-5: Condition NYMNPA 24 Noise from Blasting

NYMNPA 24	Compliance with Condition NYMNPA-24
Noise levels (air overpressure) from blasting shall not exceed 115dB (linear peak) as measured at any residential properties. No blasting shall take place outside the period 0700 until 2200 unless agreed in advance in writing by the MPA and it can be demonstrated that there will be no significant adverse noise effect on residents.	Section 2 and Section 5

Table 1-6: Condition NYMNPA 27 Blasting Vibration Limits - Daytime

NYMNPA 27	Compliance with Condition NYMNPA-27
Day time (07.00 hrs to 19.00 hrs) ground vibration as a result of underground chamber construction or blasting operations involved in shaft sinking shall not exceed a peak particle velocity of 6 mm/sec in 95% of all blasts measured over any period of 6 months and no individual blast shall exceed a peak particle velocity of 10 mm/s as measured at vibration sensitive buildings. Evening (19.00 to 22.00 hrs) ground vibration as a result of underground chamber construction or blasting operations involved in shaft sinking shall not exceed a peak particle velocity of 4.5 mm/sec in 95% of all blasts measured over any period of 6 months and no individual blast shall exceed a peak particle velocity of 6 mm/s as measured at Vibration Sensitive Buildings and Infrastructure.	Section 2 and Section 5

Table 1-7: Condition NYMNPA 28 Blasting Vibration Limits - Nighttime

NYMNPA 28	Compliance with Condition NYMNPA-28
Night time (22:00 hrs to 07.00 hrs) ground vibration from construction/blasting shall not exceed a peak particle velocity of 2 mm/s in 95% of blasts at residential properties and no individual blast shall exceed a peak particle velocity of 3 mm/s as measured at Vibration Sensitive Buildings and Infrastructure.	Section 2 and Section 5

1.1.8 In this document, the term *"construction"* includes all physical and related engineering and construction activities associated with the Phase 11 Works, as described above. Updates to this plan will be prepared and submitted to the NYMNPA for approval in advance of subsequent construction phases and following any material design or method change.

2 GUIDANCE

2.1 Legislation and British Standards

2.1.1 Wherever practicable, construction will be carried out in accordance with:

- BS 5228:2009+A1:2014 *Code of Practice for noise and vibration control on construction and open sites*.

2.2 Construction Limits

2.2.1 Established construction noise limits (as measured at the identified receptors) remain as:

- 55 dB $L_{Aeq,1hr}$ for daytime (07:00 – 19:00);
- 65 dB $L_{Aeq,1hr}$ for the demolition of buildings and erection of new structures;
- Up to 70 dB $L_{Aeq,1hr}$ for temporary noisy operations to provide noise-reducing earth bunds and / or barriers; and
- 42 dB $L_{Aeq,1hr}$ for evening and night-time (19:00 – 07:00).

2.2.2 Established blasting vibration limits (peak particle velocity, PPV, as measured at the identified receptors) are:

- 6 mm/sec in 95% of all blasts, 10 mm/s in individual blasts for blasting during daytime (07:00 to 19:00);
- 4.5 mm/sec in 95% of all blasts, 6 mm/s in individual blasts for blasting during the evening (19:00 to 22:00); and
- 2 mm/sec in 95% of all blasts, 3 mm/s in individual blasts for blasting during the night (22:00 to 07:00).

2.2.3 Established limits for air overpressure noise levels (from blasting), as measured at any residential properties are:

- shall not exceed 115dB (linear peak).

2.2.4 No blasting shall take place outside the period 0700 until 2200 unless agreed in advance in writing by the MPA.

2.3 Construction Method

2.3.1 Contractors responsible for implementing these Phase 11 Works (see Construction Environmental Management Plan (CEMP; reference 40-RHD-WS-70-EN-PL-0041)) have provided details of the construction plan, number and type of plant items to be used and location/duration of construction activities within the site. Further detail is provided in the Phase 11 Construction Method Statement (CMS) (reference 40-SMP-WS-7100-PA-MS-00009).

2.3.2 **Appendix C** details the plant items used within the model, their sound power level and location on site. Predictions of noise levels based upon these details are assessed within this NVMP.

3 PREDICTED CONSTRUCTION NOISE AND VIBRATION LEVELS

3.1 Baseline Receptor Locations

3.1.1 Residential and recreational receptors for this NVMP remain as identified in the Environmental Statement (ES) which accompanied the planning application, in previous iterations of the NVMP (e.g. Phase 4 NVMP; document reference 40-RHD-WS-70-EN-PL-0017), and as shown in **Appendix B, Figure B1**. Whilst monitoring is not ongoing at Soulsgrave Farm it is still considered a receptor for the purposes of this NVMP.

3.2 Predicted Noise Levels

3.2.1 Noise modelling was undertaken to provide predictions of noise levels throughout the Phase. **Tables C.1 and C.2** in **Appendix C** outline the construction noise assessment predictions for the Phase 11 Works.

3.2.2 Noise levels due to construction activities in the Phase 11 Works were not predicted to exceed the agreed construction noise limits at any of the identified noise-sensitive receptors during the daytime, evening or night-time following the application of suitable measures, including activity timing and physical mitigation.

3.2.3 Whilst noise levels during the daytime are not predicted to exceed the 55dB $L_{Aeq,1hr}$ daytime limit, the higher 70dB $L_{Aeq,1hr}$ limit can be considered applicable during development of the landscape mitigation screening.

3.3 Vibration

3.3.1 In relation to all construction works, excluding blasting, ground borne vibration was considered according to the conservative approach outlined in previous NVMPs (e.g. Phase 4 document reference 40-RHD-WS-70-EN-PL-0017; see Table C.7, Appendix C for minimum set-back distances for vibration levels of reportable significance).

3.3.2 All identified sensitive receptors are at least 180m from the nearest site boundary, and the minimum distance between the primary haul route and any of the surrounding receptors is over 400m. Therefore ground-borne vibration levels due to construction works, excluding blasting, will be below levels considered to be *"just about perceptible in residential environments"*[1].

3.3.3 Details of vibration associated with blasting activities are provided in **Section 5**.

4 NOISE MONITORING PROGRAMME

4.1 Noise Monitoring

4.1.1 Continuous noise monitoring, as required by condition NYMNPA 18, is being undertaken during construction at three key residential receptor locations and seven boundary locations as described in previous NVMP (e.g. Phase 4 document reference 40-RHD-WS-70-EN-PL-0017) and shown in

[1] Planning Policy Guidance Note 24 (PPG24, 1994), Department for Communities and Local Government. This guidance has been withdrawn but remains applicable in the absence of any replacement guidance.

Appendix B, Figure B1. Sound Level Meters (SLMs) record L_{Aeq}, L_{Amax}, L_{A90}, and L_{A10} data with a *"fast"* time constant and A-weighting (see **Appendix A** for descriptions of these terms). Weather condition monitoring is carried out simultaneously.

4.1.2 A system of real time alerts enables remote monitoring of noise levels and appropriate action by Contractors. Reports are produced monthly for submission to SBC and NYMNPA, and the full dataset is presented in graphical format.

5 BLASTING VIBRATION MONITORING PROGRAMME

5.1.1 Condition NYMNPA 29 requires a scheme for monitoring of blasting vibration within 1 kilometre of the site to be submitted to the MPA for approval.

5.1.2 Subject to approval from the MPA, continuous vibration monitoring is being undertaken during blasting operations at one key residential receptor location (Parkdown Bungalow, NM1) and one on site location (boundary location BML1).

5.1.3 Monitoring is undertaken using V9000 Seismographs recording Peak Particle Velocity (PPV) and air over-pressure. The Seismographs are self-calibrating.

5.1.4 PPV at the receptors is difficult to predict as the propagation of vibration through the ground depends upon a large number of factors including geological conditions between the blast location and receptor and maximum instantaneous charge weight per delay.

5.1.5 For this reason, a series of test blasts will be carried out to ascertain the blast design (including number of delays, powder velocity, charge weight etc.) that will ensure blasting vibration limits at the receptors is not exceeded.

5.1.6 Monitoring during test blasting will be undertaken concurrently at six additional locations including locations NM2 and NM3. The results from these monitoring locations will be used to optimise the blast design using regression line analysis.

5.1.7 The continuous monitoring and monitoring during test blasting will be undertaken in accordance with BS 7385:1990 Evaluation and measurement for vibration in buildings, Part 1 Guide for measurement of vibrations and evaluation of their effects on buildings.

5.1.8 The results from the blasting vibration monitoring will be forwarded to the Local Planning Authority on a quarterly basis until the end of such blasting activities.

6 MITIGATION AND PROCEDURES

6.1 Purpose of the Section

6.1.1 This section outlines measures to be taken by the Contractors to limit, and manage the impact of, noise. This section also outlines the Best Practicable Means and specific mitigation actions to be adopted.

6.2 Best Practicable Means

6.2.1 The Control of Pollution Act (1974) and BS 5228:2009+A1:2014 define working methods and mitigation measures referred to as Best Practicable Means (BPM). Appropriate BPM set out in previous NVMPs (e.g. Phase 4, reference 40-RHD-WS-70-EN-PL-0017), will continue to be applied to the Phase 11 Works.

Management Structure and Responsibilities

6.2.2 While overall responsibility for compliance with environmental and approvals requirements will remain with Sirius Minerals, all Contractors working on site are accountable for undertaking the construction activities in accordance with the requirements of this NVMP.

6.2.3 The CEMP (reference 40-RHD-WS-70-EN-PL-0041) provides details of the lines of responsibility for environmental management (including relating to robust implementation of noise management and mitigation measures) during the Phase 11 Works.

Maintenance

6.2.4 Maintenance of plant will be carried out routinely and in accordance with the manufacturers' guidance. Daily inspections will be undertaken as described in previous NVMPs (e.g. Phase 4, reference 40-RHD-WS-70-EN-PL-0017).

Training

6.2.5 The site induction programme and site rules will include good working practice instructions for site staff, managers, visitors and contractors to help minimise noise, as set out in previous NVMPs (e.g. Phase 4, reference 40-RHD-WS-70-EN-PL-0017).

6.3 Specific Mitigation

Activity timing and barriers

6.3.1 Crushing of extracted material within the materials handling area will not be undertaken between 19:00 and 07:00, unless and until it can be demonstrated that no exceedance of the noise limits would occur.

6.3.2 Condition NYMNPA 20 establishes a daytime (07:00 to 19:00) noise limit relating to the Woodsmith Mine site, specifically for temporary noisy operations which allow for the construction/reduction of earth bunds and or barriers as detailed in Table 1-2. The condition stipulates an upper limit of 70dB $L_{Aeq,1hr}$ which is applicable for up to 56 days in any calendar year and would apply to these Works.

6.3.3 Placement of extracted material onto the Bund F tipping area will not be undertaken between 19:00 and 07:00 until the berm profile is established to a sufficient height and width to ensure adequate screening at the closest receptor (Parkdown Bungalow). The berm will be graded during the daytime (07:00 to 19:00) only before night-time tipping or Bund F grading activity commences. Material tipping can occur on the materials handling area at night.

6.3.4 Where extracted material is not suitable for immediate placement into screening berms, shipping containers may be placed on the materials handling area to provide temporary screening.

6.4 Communications

Procedure for complaints or exceedance of limits

6.4.1 The procedures to be followed in the event of a complaint or an exceedance of permitted noise limits will remain as set out in previous NVMPs (e.g. Phase 4, reference 40-RHD-WS-70-EN-PL-0017).

Public relations

6.4.2 Good public relations with local residents in nearby noise-sensitive receptors will be maintained.

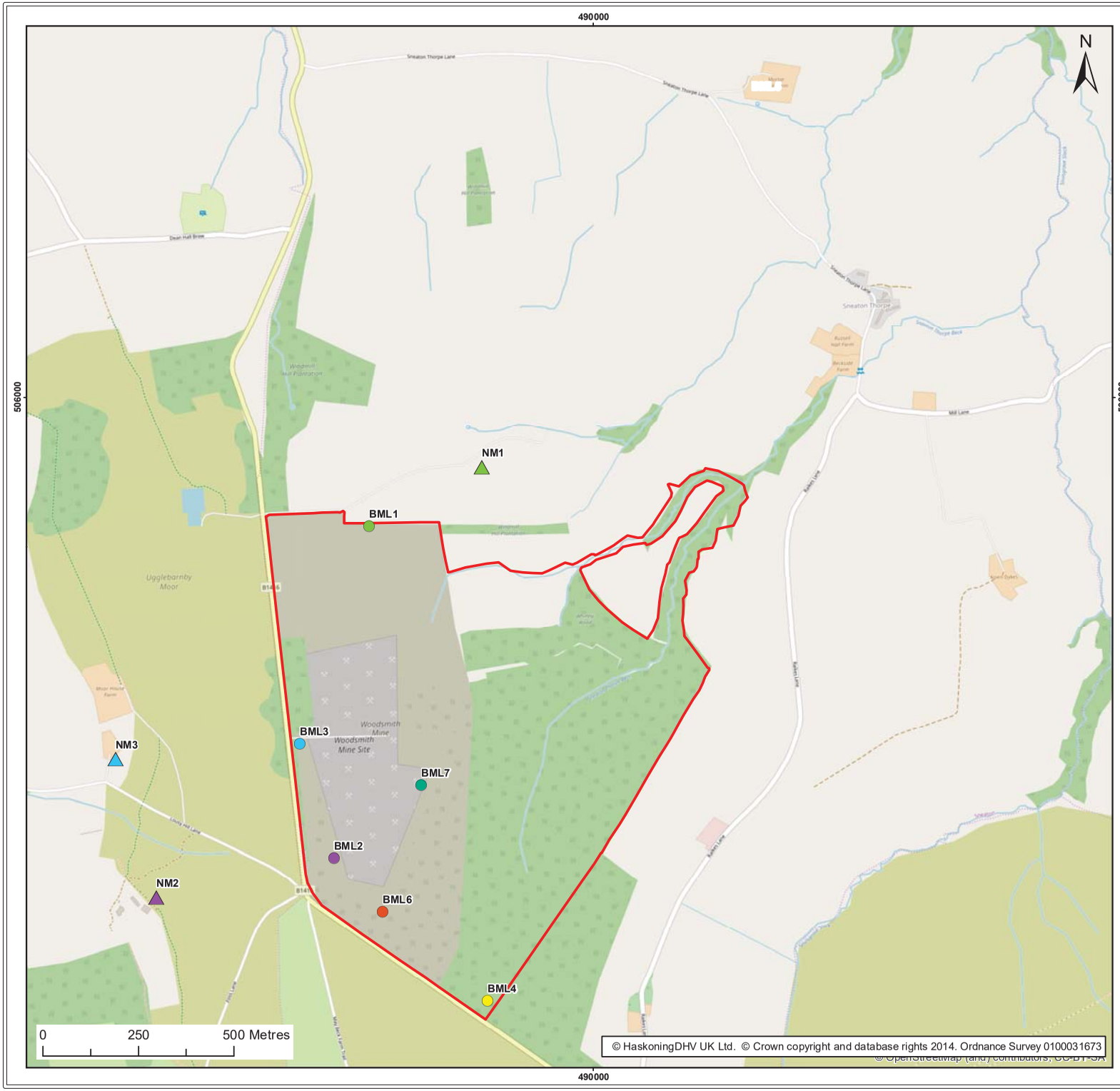
6.4.3 A Community and Stakeholder Engagement Plan is provided in Appendix A to the Phase 11 CEMP (40-RHD-WS-70-EN-PL-0041). It remains valid for Phase 11 Works, and details actions to be taken by Sirius Minerals plc and the Contractors.

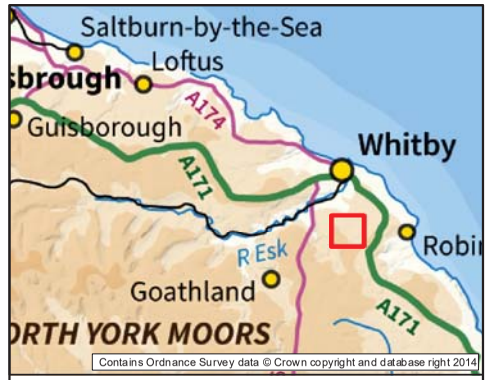
6.4.4 A Scheme for the Prior Notification of Blasting (40-SMP-WS-1000-PA-PL-00001) was approved as part of the Phase 7 Works at Woodsmith and contains details of the procedures adopted for informing local residents of blasting operations.

Appendix A Acoustic Terminology

Term	Definition
Noise sensitive receptors	People, property or designated sites for nature conservation that may be at risk from exposure to noise and vibration that could potentially arise as a result of the proposed development/project
Noise and Vibration study area	The area assessed for noise and vibration impacts during this assessment
Baseline scenario	Scenarios with the proposed development/project not in operation
Decibel (dB)	A unit of noise level derived from the logarithm of the ratio between the value of a quantity and a reference value. It is used to describe the level of many different quantities. For sound pressure level the reference quantity is 20 µPa, the threshold of normal hearing is 0dB, and 140dB is the threshold of pain. A change of 1dB is only perceptible under controlled conditions. Under normal conditions a change in noise level of 3dB(A) is the smallest perceptible change.
dB(A)	Decibels measured on a sound level meter incorporating a frequency weighting (A weighting) which differentiates between sounds of different frequency (pitch) in a similar way to the human ear. Measurements in dB(A) broadly agree with people's assessment of loudness. A change of 3 dB(A) is the minimum perceptible under normal conditions, and a change of 10 dB(A) corresponds roughly to halving or doubling the loudness of a sound. The background noise level in a living room may be about 30 dB(A); normal conversation about 60 dB(A) at 1 metre; heavy road traffic about 80 dB(A) at 10 metres; the level near a pneumatic drill about 100 dB(A).
$L_{Aeq,T}$	The equivalent continuous sound level – the sound level of a notionally steady sound having the same energy as a fluctuating sound over a specified measurement period (T). $L_{Aeq,T}$ is used to describe many types of noise and can be measured directly with an integrating sound level meter.
$L_{A10,T}$	The A weighted noise level exceeded for 10% of the specified measurement period (T). L_{A10} is the index generally adopted to assess traffic noise
$L_{A90,T}$	The A weighted noise level exceeded for 90% of the specified measurement period (T). In BS 4142:2014 it is used to define the 'background' noise level.
L_{Amax}	The maximum A-weighted sound pressure level recorded during a measurement.
PPV	Instantaneous maximum velocity reached by a vibrating element as it oscillates about its rest position.
'A' weighting	A frequency weighting to compensate for the varying sensitivity of the human ear to sound at different frequencies.
Fast time constant	Sound level meters have two conventional time weightings, F = Fast and S = Slow with time constants of 125 ms and 1000 ms respectively. Fast time constant relates to the response time of the meter which allows rapid variations in noise level to be registered.

Appendix B Figures





Legend:

Land Ownership Boundary

Site Boundary Monitoring Locations

- BML1 - Parkdown Bungalow
- BML2 - Thornhill
- BML3 - Moorside Farm
- BML4 - Soulsgrave Farm/Wainwright Coast to Coast Walk
- BML6 - Sneaton Foss/Falling Foss
- BML7 - Between shaft sinking area and BML4

Receptor Monitoring Locations

- NM1 - Parkdown Bungalow
- NM2 - Thornhill
- NM3 - Moorside Farm

Client:	Project:
Sirius Minerals plc	Sirius North Yorkshire Polyhalite Project

Title: Proposed Residential Receptor and Boundary Noise Monitoring Locations

Appendix:	Figure:	Drawing No:
B	B.1	40-RHD-WS-70-EN-PL-0016-D001

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B	16/10/2018	JT	AB	A3	1:10,000
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Co-ordinate system: British National Grid

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Appendix C Predicted Construction Noise Levels

The predicted noise levels detailed within the tables below are considered to represent the most conservative scenario.

Table C.1 Calculated highest noise levels during Phase 11 – Daytime

Receptor Location	Daytime (07:00–19:00)	
	Limit $L_{Aeq,1hr}$ dB	Maximum Predicted $L_{Aeq,1hr}$ dB
Parkdown Bungalow	55	51.0
Moor House Farm	55	38.5
Moorside Farm	55	36.6
Thornhill	55	37.0
Soulsgrave	55	41.5
Wainwright Coast to Coast Path	55	40.0
Sneaton Foss Caravan Park	55	39.0
Falling Foss Tearooms	55	21.6
Lound House Caravan Park	55	40.4

Table C.2 Calculated highest noise levels during Phase 11 – Evening and night time

Receptor Location	Evening and Night-time (19:00–07:00)	
	Limit $L_{Aeq,1hr}$ dB	Maximum Predicted $L_{Aeq,1hr}$ dB
Parkdown Bungalow	42	41.9
Moor House Farm	42	35.7

Receptor Location	Evening and Night-time (19:00–07:00)	
	Limit $L_{Aeq,1hr}$ dB	Maximum Predicted $L_{Aeq,1hr}$ dB
Moorside Farm	42	33.8
Thornhill	42	33.3
Soulsgrave	42	37.6
Wainwright Coast to Coast Path	42	36.0
Sneaton Foss Caravan Park	42	35.1
Falling Foss Tearooms	42	16.5
Lound House Caravan Park	42	33.7

During the past year, visits have been made to the various receptors for equipment maintenance and monitoring purposes. At those receptors to the south and west of the site (particularly Moorside, Thornhill and the Wainwright Coast to Coast Path) it was observed, over a number of visits, that site noise is generally inaudible. Predicted noise levels in the tables above can, therefore, be considered to be a very conservative case.

Modelling Assumptions

Concurrent Phase 4, 4a, 5, 6, 7 and 9 activities were logarithmically added to the modelled results for Phase 11, where appropriate, to produce the noise levels in Tables C.1 and C.2.

The predicted night-time levels in Table C.2 include a screen between the closest boundary of the works to the nearest receptor (Parkdown Bungalow). The screen will be graded during the daytime (07:00 to 19:00) only until it is of sufficient dimensions. The profiled screen will ensure adequate attenuation from on-site works, before night-time tipping or grading activity commences on Bund F. Nighttime operations on the materials handling area do not require any specific screening.

The following Phase 11 equipment and associated sound power levels were used within the SoundPLAN noise models:

Tree Clearance
1no. Harvester (Backhoe mounted chainsaw), 115 dB(A), 20% daytime ontime

Batteries
4x AVK container units, 68 dB(A) @1m continuous operation

Development of mitigation screening
5x Dozer, 109 dB(A), 75% ontime daytime only
1x Front end loader, 107dB(A), 75% ontime
1x Dump truck, LwA 110 dB(A), 60min/hr daytime, 30min/hr night to Material Handling Platform
1x Dump Truck LwA 110 dB(A), 60min/hr daytime, 30min/hr night to Bund F tipping area
1x Dump truck tipping, 107dB(A) (measured on site), 15min/hr
1x Mobile Crusher, 109dB(A), daytime only 20% on-time daytime only

Grout shed and winches
1x Grout Shed operations, 80dB(A), continuous operation
1x Winch, 100dB(A), continuous operation

Service Shaft Ventilation and Dust Silencer
1x Silencer, 88dB(A), continuous operation
1x Ventilation unit, 88dB(A) continuous operation
1x Service Shaft Winch House, LwA 100dB, continuous operation
1x Winch House PS, LwA 100dB, continuous operation
1 x PS ventilation, 88dB(A), continuous operation

Air Compressing Facility
5x Compressors LR290, 90 dB(A), 100%
2x Condensates pumps, 80.5 dB(A), 100%
1x Adsorption Dryer, 106 dB(A), 100%

NDWWTP
1x Dissolved Air Flotation Unit, 93.1 dB(A), 80% on time, daytime only
3x Shaft Head Shaker Unit, 97.7 dB(A), 80% on time daytime only at MTS shaft, North and South shafts

Mobile equipment was modelled as a moving point line source with speeds of between 5 and 20 kph. Stationary plant was modelled as a point source.

Noise propagation was calculated using the BS 5228:2009+A1:2014 methodology.

NYMNPA

29/07/2019

SIRIUS MINERALS PLC

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Document Title:

PHASE 11 PROTECTED SPECIES MANAGEMENT PLAN (PSMP) - BATS

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REPORT

Phase 11 - Woodsmith Mine Protected Species Management Plan - Bats

Woodsmith Mine Phase 11 - PSMP Bats

Client: Sirius Minerals PLC

Reference: 40-RHD-WS-70-EN-PL-0043 REV 0

Status: 01/Final

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Table of Contents

1 Introduction

1.1 Purpose of Document

1.1.1 In 2014 a planning application (reference NYM/2014/0676/MEIA) was submitted to the North York Moors National Park Authority (NYMNPA) for permission to develop a polyhalite mine and underground Mineral Transport System (MTS). Planning permission was subsequently granted in 2015 subject to conditions, as varied in February 2018 by NYM/2017/0505/MEIA.

1.1.2 This document has been prepared on behalf of Sirius Minerals plc (Sirius Minerals) and applies to the Phase 11 works at Woodsmith Mine, as described in **paragraph 1.2** below.

1.1.3 This document has been prepared to incorporate the findings of a bat and lighting survey that was undertaken by INCA in April 2019. This document should be read in conjunction with the Phase 9 Protected Species Management Plan (PSMP) for bats (40-RHD-WS-70-EN-PL-0039), and the information herein supersedes the Phase 9 documentation only where specified.

1.1.4 The works at Woodsmith Mine, as outlined in the Phase 9 PSMP for bats, have been subject to a Bat European Protected Species Licence (EPSL). The Phase 3 PSMP for bats should be read for information in respect to the survey work that has been undertaken. This document provides only the information relating to the findings and recommendations of the June 2019 bat and lighting survey.

1.1.5 This document is required to partially satisfy the requirements of NYMNPA-52. This planning condition states that:

Table 1-1 Condition NYMNPA-52 Protected Species Management Plan - Bats

Condition	Compliance with Condition NYMNPA-52
Protected Species Management Plans (PSMPs) shall be submitted to the MPA [Mineral Planning Authority] prior to the commencement of each Phase of Construction which shall not commence until the PSMPs have been agreed in writing by the MPA	This version of the PSMP for bats is for Phase 11 as defined in Section 1.2 below. Earlier Works were covered by a previous version of this PSMP (40-RHD-WS-70-EN-PL-0013 and 40-RHD-WS-70-EN-PL-0039).
The agreed details shall subsequently be followed unless modifications are agreed in writing by the MPA.	
The PSMPs may establish a programme of submissions to the MPA such that details are approved prior to works affecting different species and areas of the sites, shall concern protected species affected directly by works at the Dove's Nest Farm and Lady Cross Plantation sites, shall detail minimum requirements for mitigating or compensating for effects on protected species, shall require all licences that may be required in respect of effects on or re-location of protected species and their habitat to be obtained and complied with, and shall include but not be limited to consideration of the following a. Bats (all species) b. Badger	This PSMP relates to bats only.

Condition	Compliance with Condition NYMNPA-52
c. Adder d. Common lizard particularly at western side of Lady Cross Plantation e. Other protected reptiles f. Water vole g. Common Crossbill h. Goshawk	

1.1.6 This document details measures that are required for the Phase 11 Works at Woodsmith Mine for the protection of bats. It does not include any activities at Lady Cross Plantation as these Works have been deferred. Updates to this Plan will be prepared for subsequent construction Phases and following any design or method change. The NYMNPA, as well as the Environment Agency and Natural England, agreed that they support this approach in meetings held in April 2016.

1.2 Phase 11 Works

1.2.1 The Phase 11 Works comprise the following:

- Development of landscape mitigation screening;
- Tree clearance within Haxby Plantation;
- Sinking of the MTS shaft via drill and blast method;
- Operation of the Galloway;
- Creation of a materials handling area;
- Installation of external silencer to the dust collector of the Service Shaft building; and
- Installation of batteries.

2 Relevant legislation and guidance

2.1.1 There have been no changes in the relevant legislation afforded to bats since the Phase 3 PSMP (reference 40-RHD-WS-70-EN-PL-0013) and therefore the information contained in the Phase 3 PSMP remains valid.

2.1.2 There have been no further updates to the guidance in respect of artificial lighting and bats within the UK since the Phase 9 PSMP (reference 40-RHD-WS-70-EN-PL-0039) and therefore the information contained in the Phase 9 PSMP remains valid.

3 Recent survey work

3.1.1 One of the additional mitigation measures provided in the updated bats and artificial lighting guidance included the requirement that:

- Dark habitat buffers will be identified by a suitably qualified bat ecologist. The Contractor or their agents will ensure that any artificial lighting is not used in or adjacent to these areas.

3.1.2 To fulfil this requirement, INCA, in conjunction with Paul Chester Associates, undertook a bats and lighting survey in April 2019. This concluded that:

- The northern and western boundaries are Dark Habitat Buffers and therefore no lighting is to be placed within these areas; and
- The corridors in and around Haxby Plantation remain as they were prior to the commencement of works associated with the development.

3.1.3 The April 2019 survey also identified several (minor) actions for the site team to be aware of and address, e.g. closure of window shutters to reduce light spillage. All of the actions identified following the April 2019 survey have been addressed by Sirius Minerals and therefore no further action is required.

4 Mitigation

4.1 Mitigation and Good Practice Measures

4.1.1 The following measures (as previously stated in the Phase 3 and Phase 9 PSMP) will continue to be adhered to, where safe and practicable, during future Works as appropriate to safeguard bats.

- Relevant staff working on site (with the potential to encounter bats or with lighting responsibilities) will be required to attend a tool box talk about the potential presence of bats. Elements of this will include what constitutes signs of bat presence, the probable location of bats, their legal status and the penalties should a contractor or his agents deliberately injure or kill a bat;
- No lighting will be placed within the designated Dark Habitat Buffers to the northern and western boundaries of Woodsmith Mine;
- Shutters on buildings will be closed during the hours of darkness to prevent light spill;
- The lighting requirements for the Phase 11 Works will be designed in accordance with guidance from BCT Bats and Artificial Lighting in the UK (2018) and reviewed by a suitably qualified bat ecologist. The key design parameters will consider, but are not limited to, the following:
    - No luminaires will contain metal halide or fluorescent sources;
    - LED luminaires will be used where possible;
    - For any new lighting, a warm white spectrum (<2700Kelvin) will be adopted wherever possible or practical to reduce blue light component;
    - For any new lighting, luminaires will have peak wavelengths of no more than 550nm where possible;
    - Column heights will be appropriate to what is required to minimise light spill;
    - Luminaires will, where possible and feasible, be mounted on the horizontal, with no upward tilt; and
    - Any external security lighting, if required, will be set on motion sensors and with timers set to a short period (acknowledging health and safety requirements).

NYMNPA

29/07/2019

SIRIUS MINERALS PLC

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Document Title:

REMEDIAL ACTION PLAN (RAP) PHASE 11 - NYMNPA 46- PHASE 11)

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FWS Geological & Geo-Environmental Consultants

SIRIUS MINERALS PLC - DISCHARGE OF PLANNING CONDITIONS FOR PLANNING APPLICATION NYM/2017/0505/MEIA, NORTH YORKSHIRE POLYHALITE PROJECT

CONDITION	NYMNPA 46
REPORT	REMEDIAL ACTION PLAN
SITE	PHASE 11 WORKS AT WOODSMITH MINE, NORTH YORKSHIRE
DOCUMENT NUMBER	40-FWS-WS-70-WM-PL-0024

1433DevOR445 Rev 1/July 2019

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PROJECT NUMBER	1433			
PROJECT TITLE	North Yorkshire Polyhalite Project			
CLIENT	Sirius Minerals plc 7-10 Manor Court Manor Garth SCARBOROUGH YO11 3TU			
REPORT TITLE	Remedial Action Plan for the Phase 11 Works At Woodsmith Mine, North Yorkshire			
REPORT REFERENCE	1433DevOR445 Rev 1			
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CONTENTS

APPENDICES

REMEDIAL ACTION PLAN FOR THE PHASE 11 WORKS AT WOODSMITH MINE, NORTH YORKSHIRE

1 INTRODUCTION

1.1 General Background

This document has been prepared on behalf of Sirius Minerals plc and provides the Remedial Action Plan for the Phase 11 Works at the Doves Nest Farm Minesite (Phase 11 Works) that will run concurrently with the Phase 7 to 10 works. This is required to satisfy Condition 46 of the North York Moors National Park Authority (NYMNPA) planning permission NYM/2014/0676/MEIA (as varied by NYM/2017/0505/MEIA).

This document details the remedial actions required should monitoring, undertaken in accordance the Ground and Surface Water Monitoring Scheme for the Phase 11 Works (Ref. 1), identify exceedances to the defined Trigger Values.

1.2 Objectives

The purpose of this document is to:-

- Provide a list of individuals (and their contact details) who are responsible for identifying and investigating a Trigger Value exceedance;
- Provide a procedure for investigating and escalating a Trigger Value exceedance, and for informing the appropriate regulator (the Environment Agency);
- Provide a list of individuals and organisations to be informed in the event of a exceedance or a confirmed departure from the established baseline;
- Detail actions to protect the environment in the event of a suspected or confirmed environmental incident or departure from the established baseline.

1.3 Phase 11 Works

Provided below are details of the proposed Phase 11 Works, which will be undertaken concurrently with the ongoing Phase 7 to 10 works.

Phase 11 Works

- Development of landscape mitigation screening;
- Tree clearance within Haxby Plantation;
- Sinking the MTS shaft via drill and blast method;
- Operation of the Galloway;
- Creation of a materials handling area;
- Installation of external silencer to the dust collector of the Service Shaft building;
- Installation of batteries.

Ongoing Construction Works at the Woodsmith Mine Site

- Phase 7 Completion of Service Shaft excavation to 83.17m AOD;
- Phase 7 Excavation of Production Shaft Headgear Chamber to 158.16m AOD;
- Phase 7 Excavation of Production Shaft to 83.66m AOD;
- Phase 8 Construction of permanent Service Shaft building, including installation of the winder equipment;
- Phase 8 Construction of permanent Production Shaft building, including installation of the winder equipment;
- Phase 9 installation of secure storage unit;
- Phase 9 assembly and installation of Galloway into MTS Shaft;
- Phase 9 installation and operation of first stage of non-domestic wastewater treatment plant (NDWWTP);
- Phase 10 Mechanical excavation and grouting of Service Shaft to 83.17 m AOD to install a temporary precast concrete segmental liner with back grouting followed by installation of the permanent secondary cast insitu concrete; and
- Phase 10 Piling to the floor slab in the head frame chamber will be undertaken after completion of installing the hydrostatic liner.

1.4 Compliance with Conditions

Table 1 sets out the wording of Planning Condition 46 to Planning Consent Ref No. NYM/2017/0505/MEIA and details where the relevant material, to comply with this condition, has been provided within this report: -

Table 1 - Summary of Planning Condition 46 and Where Relevant Details Are Provided In This Report

NYMNPA Condition 46	Compliance with Condition 46
The Remedial Action Plan shall include: -	
The remedial actions to be taken in the event that any monitoring triggers of the approved Construction and Operational Phase Ground and Surface Water Monitoring Scheme are exceeded.	Sections 3 to 5

2 RESPONSIBILITIES AND CONTACTS

2.1 Parties Responsible for Identifying and Investigating a Trigger Value Exceedance

Table 2 presents the details of the individuals and their contact information for the parties responsible for identifying and investigating a Trigger Value exceedance.

Table 2 - Parties Responsible for Identifying and Investigating a Trigger Value Exceedance

Contact Name	Position	Company	Contact Details	Responsibility
Robert Staniland	Environment Manager	Sirius Minerals	Resolution House Lake View Scarborough YO11 3ZB	Coordination of Environmental Activities within the Development
Charlotte Bell Zoe Cooper John Surphliss	Environmental officers			Monitoring of ground and surface water in accordance with the Ground Water Management Scheme.

Contact Name	Position	Company	Contact Details	Responsibility
Graham Clarke	Project Manager	Sirius Minerals		Operation of the NDWWTP

2.2 Parties to be informed in the Event of a Exceedance/Departure from Baseline Conditions

In accordance with Condition 46 of planning permission NYM/2017/0505/MEIA, Table 3 presents those individuals and organisations who are to be informed in the event of a exceedance or a confirmed departure from the established baseline conditions: -

Table 3 Parties to be informed in the Event of a Exceedance/Departure from Baseline Conditions

Contact Name	Position	Company/ Regulatory Body	Contact Details
Robert Staniland	Environment Manager	Sirius Minerals	Resolution House, Lake View, Scarborough, YO11 3ZB
Graham Clarke	Project Manager	Sirius Minerals	
Fraser Thomlinson / Ruth Buckley	Planning Liaison Officer / Yorkshire Area Groundwater and Contaminated Land Team	Environment Agency	Lateral, 8 City Walk, Leeds, LS11 9AT
Rob Smith,	Senior Minerals Planner	North York Moors National Park Authority	The Old Vicarage, Bondgate, Helmsley, York, North Yorkshire YO62 5BP
Merlin Ash	Yorkshire and Northern Lincolnshire Team	Natural England	Hornbeam House, Crewe Business Park, Electra Way, Crewe, Cheshire CW1 6GJ

3 PROCEDURE FOR EVALUATING EXCEEDANCES IN TRIGGER VALUES

3.1 General

A Ground and Surface Water Monitoring Scheme (Ref. 1) has been prepared detailing the monitoring requirement for the Phase 11 Works. That document details the groundwater, spring water, surface water and ecological monitoring to be undertaken to identify what physical or chemical impacts are occurring from the Phase 11 Works undertaken concurrently with the ongoing Phase 7 to 10 works.

The Ground and Surface Water Monitoring Scheme (Ref. 1) details the Control and Compliance Trigger Values that the monitoring data will be assessed against.

Where exceedances of the Control Trigger Values occur, the procedure to evaluate and record the remedial actions required, will be as set out in Section 3 of the Remedial Action Plan.

3.2 Environmental Groundwater Level Evaluation

3.2.1 Groundwater Levels Assessment Procedure

Details of the groundwater level monitoring locations are presented in Section 2.3 of the Construction and Operation Ground and Surface Water Monitoring Scheme (Ref 1) and the locations are shown in Drawing 1433DevOR410.

The results will be compared with baseline data and the Control and Compliance Trigger Values to identify any exceedances.

Appendix 1.1 presents the procedure for assessing exceedances of groundwater level (GWL) Control and Compliance Trigger Values at the environmental groundwater level monitoring points during the Phase 11 Works. It presents a summary of the sequence of activities and respective timescales for each stage, for which details are provided below.

3.2.2 Consultation with Project Manager and Planning Remedial Actions

The recorded exceedance of either GWL Control or Compliance Trigger Values will be evaluated by the Environmental Engineer in consultation with the Project Manager to determine the cause of the exceedance and the appropriate course of remedial action that will be taken.

An exceedance of the GWL Control or Compliance Trigger Values for individual boreholes will be assessed in conjunction with the rainfall data for the preceding period, to ascertain whether the exceedance is due to natural climatic conditions or as a result of the Phase 7 to 11 Works.

The recorded exceedance will be classed as either: -

- A natural (non-site related) exceedance of the GWL Control or Compliance Trigger Value, caused by natural variations in rainfall (i.e. low rainfall).
- An exceedance of the GWL Control or Compliance Trigger Value, caused by the Phase 7 to 11 Works.
- An exceedance of the GWL Control or Compliance Trigger Value, caused by non-Phase 7 to 11 related offsite works.

Where the exceedance is found to be caused by natural climatic conditions or non-Phase 7 to 11 related works, they will be recorded as such and no further remedial actions will be required.

The remedial actions will be designed specific to the degree of exceedance (i.e. physical change in groundwater levels), the location where the exceedance was recorded, and the likely cause of this exceedance.

3.2.3 Implementing Remedial Actions

Where remedial actions are specified by the Environmental Officer, related to an exceedance in either GWL Control or Compliance Trigger Values, they will be advised to the Project Manager, the Environment Manager and the Regulators (as detailed in Section 2.2), and implemented by the Project Manager.