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STAFFORDSHIRE MOORLAND DISTRICT COUNCIL

MONEYSTONE QUARRY

PEER REVIEW (STABILITY)

JUNE 2022

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STAFFORDSHIRE MOORLAND DISTRICT COUNCIL

MONEYSTONE QUARRY

PEER REVIEW (STABILITY)

JUNE 2022

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APPENDICES

DRAWING NUMBER	TITLE	SCALE
GM12292-001	Site Location Plan	1:10,000
GM12292-002	Photograph Survey Location	1:2,500

TABLE NUMBER	TITLE
Table 1.1	Summary of Peer Review Documents

1 INTRODUCTION

1.1 Commission

1.1.1 Wardell Armstrong LLP (WA) were commissioned by Jane Curley of Staffordshire Moorland District Council (SMDC) under PO Number 100028581 (04/05/2022) to carry out a Stability Peer Review of three reports for Quarry 3 of Moneystone Quarry, submitted in support of a planning application for the redevelopment of the Quarry into a leisure facility.

1.2 Background

1.2.1 Outline planning application (SMD/2016/0378) has been granted for the development of a leisure facility including 250 lodges within the former Moneystone Quarry. A reserved matters planning application (reference SMD/2019/0646) is currently under review by SMDC for Phase 1 of the project, which includes Quarry 1 (Q1) and Quarry 3 (Q3) and addresses appearance, scale, layout and landscaping of 190 lodges, a new central hub building and associated works.

1.2.2 As part of the National Planning Policy Framework, SMDC are required to ensure that *'…a site is suitable for its proposed use taking account of ground conditions and any risks arising from land stability and contamination'*. WA have been informed that contamination has been advised on and therefore it is not considered within this report. WA have been commissioned to review the submitted Abbeydale Building Environment Consultant (Abbeydale BEC) reports to assist with the Council's decision by providing a Peer Review assessment on whether there is a risk to the proposed development from land stability and whether the level of investigation and assessment presented is appropriate to support the planning application.

1.2.3 A more recent planning application (reference SMD/2022/0014) has been submitted with plans to construct a revised surface water outfall at Q3 and retain the lake water level at 156 metres above Ordnance Datum (m AOD). However, the data supporting this revised application is outside the scope of this review.

1.3 Sources of Information

1.3.1 The documents reviewed as part of the Peer Review (Stability) are listed in Table 1.1. Further information provided on the SMDC planning portal has also been reviewed for context, but a detailed review of that information or the documents referenced in the three reports below was not part of the commission.

Table 1.1 Summary of Peer Review Documents

Document Title	Author	Date	Document Reference	Reference (in this report)
Geotechnical and Hydrological Factual Report Parts 1 to 3	Abbeydale BEC	September 2018	418055GR	[1]
Overview Site Investigation Report Moneystone Staffordshire	Abbeydale BEC	October 2018	418055SI	[2]
Q3 – Moneystone Quarry – Safety and Stability Statement	Abbeydale BEC	5th October 2020	418058	[3]

1.4 Report Limitations

1.4.1 As previously stated, only the three reports referenced in Table 1.1 have been reviewed in detail, and other reports relating to Moneystone Quarry have not been assessed by WA.

1.4.2 Third party information has been reviewed as part of this assessment, and the factual data is assumed to be correct. WA are not liable for any inaccuracies, errors or omissions associated with third party data searches and factual information.

2 STABILITY PEER REVIEW

2.1 Geotechnical and Hydrological Factual Report Parts 1 to 3 [1]

Scope of Ground Investigation (Q3 Area A & C)

2.1.1 The ground investigation designed and supervised by Abbeydale BEC between January 2018 and July 2018 within Area A on the southern slope of Q3 and Area C on the northern slope of Q3 comprised:

- Three rotary cored boreholes (A-BH1, A-BH2 and C-BH1);
- Trial pitting (18 No.); and
- Exposure logging of selected quarry faces.

2.1.2 Three rotary exploratory holes were drilled in Q3 with rock cores obtained and logged. A-BH1 was drilled to 12m below ground level (BGL), A-BH2 was drilled to 5.40m BGL and C-BH1 was drilled to 17.80m BGL and encountered the base of the sandstone and top of the shale.

2.1.3 Point load testing (PLT) has been carried out on selected core samples with additional samples from a previous investigation dated 30/10/2015. In addition, three Uniaxial Compressive Strength (UCS) tests were undertaken on selected rock core samples, one from each borehole.

2.1.4 PLT is a quick and simple way of obtaining strength parameters of a rock. The PLT value is then converted to UCS using a conversion factor which is dependent on the rock type. UCS tests can be used to validate the results of the PLT and define the conversion factor. However, arbitrary ratio values can also be used although this can result in over or underestimation of the UCS of the rock. Abbeydale BEC have used an arbitrary conversion factor which does not appear to have been validated by any UCS testing.

2.1.5 The reported UCS of the rock core tested from A-BH1 and A-BH2 are 29.9 and 31.6 MPa respectively, i.e. a strength classification of medium strong (BS EN ISO 14689). The UCS of the rock core tested from C-BH1 is 9.7 MPa, i.e. weak (BS EN ISO 14689). Although Abbeydale BEC do not provide any discussion on the PLT or UCS test results, the reported UCS of weak to medium strong sandstone are consistent with the results of the PLT.

2.1.6 Discontinuity logging of the rock core has been carried out and presented for exploratory holes A-BH1 and A-BH2. The majority of the joints are described as rough,

open and clay infilled. There is no description of weathering, and the discontinuity descriptions are not used as part of a rock mass rating or assessment. WA would expect a geotechnical assessment of the overall rock mass to have been carried out following completion of the ground investigations.

2.1.7 Exposure logging and reporting of the Q3 eastern bench and parts of the northern face has been carried out to a good standard and Abbeydale BEC correctly suggest that further logging is required following receipt of the development proposals.

2.1.8 The results of the Q3 Rock Face Assessment are shown in Figures 5c-a to 5c-f which present the joint dip and dip direction data on stereonet projections, along with the orientation of the quarry faces. The stereonet assessment has been completed to a preliminary stage with only the data range of the main joint sets identified. The five discontinuity sets are shown on the stereonet, including bedding and a further sixth set showing the cross bedding, but the interpreted results of the assessment are not included in the report, i.e. the average dip and dip direction of each of the identified joint sets and bedding planes are not reported.

2.1.9 The next stage of the assessment has not been undertaken which would assess the potential for joint controlled failure mechanisms to occur in each of the benches and the overall slope faces. Once the failure mechanism is known for a bench or slope, the hazard can be risk assessed and the recommended control measures suggested.

2.1.10 Soil samples from trial pits in Area A have been tested for Water Content (25 No.), Atterberg Limits (4 No.), Particle Size Distribution (1 No.) and Density (1 No.). The clays in Area A range from intermediate to high plasticity, though this interpretation has not been carried out by Abbeydale BEC. Soil samples from trial pits in Area C have been tested for Water Content (28 no.), Atterberg Limits (1 No.), Particle Size Distribution (4 No.) and Density (1 No.). The one Atterberg Limit test result in Area C classifies the clay to be of intermediate plasticity. The soil testing is limited for both Areas A and C and interpretation of the results has not been carried out.

2.1.11 Excavatability graphs have been prepared by Abbeydale BEC which are considered consistent with the results of the PLT and UCS testing.

2.1.12 WA would have expected more exploratory holes and rock testing to have been carried out in Q3, including investigation points located in each of the quarry faces. For the next stage of the project, further ground investigation should be carried out

and be sufficient to inform Rock Mass Rating, kinematic and slope stability assessments.

2.2 Overview Site Investigation Report Moneystone Staffordshire [2]

2.2.1 The Overview Site Investigation Report provides a summary of the ground conditions identified following the ground investigation that was undertaken between January 2018 and July 2018. Section 9 of that report focuses on the Engineering Considerations, though there is limited interpretation or geotechnical assessment within the report.

2.2.2 The report [2] presents stability assessments of freshly exposed sandstone faces, the assessment of the overall stability of the Northern Face and the results of the Limit Equilibrium Slope Stability analysis. The Limit Equilibrium method of analysis considers the potential for failure through a soil or rock slope via slip surfaces, i.e. a characteristic land slip failure. Kinematic failures assess the potential for failure in a rock mass along joint and bedding surfaces. Both failure mechanisms can occur on small bench scale, as well as for full slope height, provided certain parameters are met. A Factor of Safety (FoS) is the industry recognised measure of confirming if a slope is stable. Kinematic failures are assessed based on the geometric ability of failures to occur, combined with the geotechnical properties of the rock mass and intact rock. Abbeydale BEC identify that a FoS of 1.3 is required for stable slopes. However, industry guidance and best practice identifies that a FoS of 1.5 for long term slopes or slopes with sensitive receptors should be used.

2.2.3 Abbeydale BEC have provided the nature and geometry of the discontinuities as part of the factual report [1]. However, Abbeydale BEC have not undertaken a rock mass characterisation assessment which would incorporate the properties of the intact rock, including the joint and bedding characteristics, weathering, strength testing and the geometry of the quarry faces and benches. The assessment of the rock mass condition would be used in kinematic (joint failure) slope stability assessments as well as developing properties for use in the land slip failure assessment.

2.2.4 At this stage of the development planning, WA would have expected a risk assessment approach to have been used to:

- identify the current geotechnical hazards;
- identify the risks to the proposed development and users;
- evaluate the risks, following stability and failure assessments;

- record the initial risk rating;
- evaluate the potential mitigation/control measures; and
- record a post mitigation risk rating for each hazard.

2.2.5 This approach would formally demonstrate that sufficient ground investigation and risk assessment has been carried out to adequately assess the stability risks within Q3.

2.2.6 The Abbeydale BEC assessment states that since 2010 the slopes in Q3 have not shown any signs of mass movement.

2.2.7 However, potential instability and minor slips have been identified on the northern face by Abbeydale BEC in their 2011 assessment. During the 2022 site visit carried out by WA, localised areas of rock failure have been identified on the slopes reviewed (the extent of the site visit is shown on Drawing Number GM12292-002).

Q3 Freshly Exposed Sandstone Rock Faces

2.2.8 Abbeydale BEC expect that cutting a 1-4m high near vertical face will, from experience, fracture and spall. For Q3 a 1m wide protection bench at the base of a freshly cut face is recommended, as well as encouraging vegetation growth [2].

2.2.9 Abbeydale BEC correctly recognise that without maintenance and control measures, the proposed vertical faces will spall which will be a hazard. Beyond spalling, the stability of the near vertical faces has not been investigated either for land slip or kinematic failures.

2.2.10 Mitigation measures in the form of a protection bench and increasing vegetation density are provided, but without the appropriate stability and kinematic assessments on the proposed slopes the mitigations should not be defined. The correct mitigation measures need to be investigated for the hazards present. The Overview Ground Investigation report does not define the hazards in Q3. Modelling of the proposed mitigation measures should be considered to determine whether a sufficient Factor of Safety (FoS) can be achieved for the development.

Overall Stability of Q3 North Face

2.2.11 The western part of the northern face has been identified as having potential instability issues and minor slips are recorded to have affected the lower bench at 155m AOD between 2010 and 2018.

2.2.12 It is likely that the operational quarry will have extracted the maximum possible resource while maintaining long term slope stability, and should have been excavated in accordance with the Quarry Regulations 1999. The north face of Q3 is an area where the bench is anticipated to be cut to widen the area for the lodges, parking and the access road and would steepen the slope profile, potentially forming additional slip surfaces. The Abbeydale BEC assessment indicates that the slope currently does not have a FoS of 1.3 and suggests additional slope support in the form of proposed earthworks would assist in the maintenance of a long term 1.3 FoS.

2.2.13 Abbeydale BEC are correct to highlight the stability concerns for Q3 and propose earthworks to increase stability. However, given the sensitive and public nature of the proposed development, a minimum FoS of 1.5 should be achieved, rather than a FoS of 1.3. WA would also expect that slope stability analysis be carried out for all slopes within Q3, not just the northern slope, and that individual analysis be conducted for each bench as well as the overall slope. The stability assessment should be undertaken for the proposed slope profiles.

2.2.14 The Abbeydale BEC assessment is based on maintaining a stable lake water level below the existing 155m AOD bench to assist slope stability, however it is understood that as part of the planning application (reference SMD/2022/0014) the required water level would be 156m AOD for the proposed development. Due to the proposed water level changes (a 1 m rise in water level), the assessment in this report should be reviewed and revised if appropriate.

2.2.15 There is no evidence of a kinematic assessment or rock fall assessment within the report which should also have been considered. A rock fall assessment investigates the failure type, energy, velocity and bounce heights of rock failure paths. Given that the proposed slopes are mainly near vertical and that residential properties and pedestrian access roads are proposed beneath and adjacent to them, an assessment of localised failure on each slope and the potential failure behaviour and interaction with the proposed benches, sensitive receptors and lake water needs to be considered to adequately model the proposed land stability within Q3.

Appendix B

2.2.16 The slope stability analysis investigates the sensitivity to sandstone weakening and lake level to the existing profile of Q3 northern face [2]. The assessment has considered seven sections or scenarios along the northern face.

2.2.17 The basis of the geotechnical parameters for the soil and rock, used as part of slope stability analysis, is unclear. The shear strength parameters for rock – sandstone and mudstone – are considered by WA to be optimistic. WA would have expected the parameters to have been derived from "site specific" rock strength testing.

2.2.18 As part of the ground investigation, particularly for Q3, WA would have expected laboratory testing to provide rock UCS, triaxial and tensile strength results to establish values of cohesion and phi (Mohr-coulomb shear strength parameters) from the material present on site. There is no evidence to suggest that the values used in the slope stability assessment are from the site or that they have been taken from appropriate published literature.

2.2.19 The assessment has been carried out on the existing slope profiles under different scenarios and suggests that the northern slope (within the site boundary) does not currently achieve a FoS of 1.3. The northern face is only considered safe by Abbeydale BEC with the addition of a gravel buttress constructed against the slope face. As the current slope is not considered safe (FoS < 1.3), the proposed slope will need to improve stability and achieve a minimum FoS of 1.5 given the nature of the proposed development, and the proposed slope profile, including loading from the lodges and vehicles on the access roads.

2.2.20 Slope profiles 2F-1 to 2H-1 consider the proposed bench profiles for the northern slopes of Q3, however there is no evidence to suggest that the other proposed slopes (west, east and south) have been assessed in terms of slope stability. Given the nature of the proposed development this must be carried out before an assessment of stability of the overall quarry can be determined.

2.3 Q3 – Moneystone Quarry – Safety and Stability Statement [3]

2.3.1 The Q3 – Moneystone Quarry – Safety and Stability Statement letter report has been prepared to address concerns of the safety and stability of Q3, and in particular the risk of landslides and tsunami waves impacting the proposed lodges.

2.3.2 Abbeydale BEC state the concerns from mass landslip and tsunami waves are unfounded should the proposed earthworks be constructed to improve stability.

2.3.3 Without evidence of sufficient slope stability analysis, rock fall assessment, kinematic assessment and a comprehensive risk assessment, the risk from mass movement and tsunami waves have not been adequately identified or mitigated.

2.3.4 Mitigation in the form of rock rubble slopes placed underwater on the northern side of Q3 are proposed to provide the designed 30% stability improvement. The Phase 1 earthworks, as presented in the Table E3 Earthworks Sequence, provides the proposed measures to be delivered as part of the development to ensure the stability and safety of Q3.

2.3.5 Abbeydale BEC correctly suggest that mitigation is required to improve stability, however slope stability analysis should be carried out on all the slopes including the proposed earthworks to inform the stability and therefore the risk to the proposed development.

2.3.6 The assessment is based on maintaining a stable lake water level below the existing 155m AOD bench to assist slope stability. It is understood that as part of the 2022 planning application (reference SMD/2022/0014) the required water level would be 156m AOD for the proposed development. Due to lake water level changes (a rise of 1m) the stability assessment should be reviewed and this letter report [3] should be revised if appropriate.

3 SITE VISIT

3.1 Attendance

3.1.1 A site visit was carried out on 10/05/2022 by Wardell Armstrong. Attending the site visit was a Technical Director experienced with the investigation and assessment of slope stability and slope design and a Principal Engineering Geologist.

3.1.2 The site visit included a walkover of the accessible parts of Quarry 3 and a Photograph Survey which is attached at Appendix D.

3.2 Review

3.2.1 The majority of the benches were overgrown which meant that access to the western and north-western faces of Quarry 3 was impossible. The north-eastern, eastern and southern faces were accessible and the extents to which the visit was carried out are shown on Drawing Number GM12292-002.

Eastern

3.2.2 At the time of the site visit the rock faces were generally of good condition, however localised block failure had occurred, and evidence of the rock fall is shown at Photo Location 2.

3.2.3 Near vertical exposed rock faces were observed from the top bench (Photo Location 4) with some spalling.

3.2.4 The bench and edge protection bund in this area, while adequate for the current quarry configuration and status, is too narrow for vehicle access and the edge protection bund is not of sufficient height or construction for vehicle access.

North-eastern

3.2.5 The north-eastern face along the top bench, that was visible from the dense vegetation cover, appeared to be in a good condition with limited evidence of rock failure (Photo Location 3). Evidence of mechanical ripping by the quarry machinery during the previous quarrying excavations was observed.

3.2.6 The north-eastern face from the lower bench was not visible due to vegetation cover (Photo Location 5).

Southern

3.2.7 Along the lower bench the southern face showed day-lighting discontinuities and loose rock material (Photo Location 8), and evidence of localised planar failure with small scale wedge failure is shown at Photo Location 9.

3.2.8 Along the track through the woodland on the southern face, the geology comprises friable mudstone (Photo Location 12) underlain by the sandstone visible in the quarry exposures. Evidence of standing water in ruts was also observed (Photo Location 14).

3.2.9 The outfall location is shown at Photo Location 13.

Western (as seen from the southern face)

3.2.10 The south-western face showed evidence of increased day-lighting discontinuities resulting in a blocky or "sugar cube" rock mass as shown at Photo Location 10.

3.2.11 Although this section is an area where small scale block failure could be possible, the proposed development is not expected to extend to, or interact with, this face with the exception of the circular access road and the proposed access bridge which will extend between the two benches in this location. It is likely that this area will therefore have prolonged vehicle and pedestrian access. No rock fall assessment has been undertaken for this area or determination of the bridge foundations.

3.2.12 The gradient of the western slope becomes shallower from south to north.

North-western (as seen from southern face)

3.2.13 The northern face is heavily vegetated and there is no evidence of a top bench (Photo Location 11). The slope dip increases from west to east.

3.3 Summary

3.3.1 Overall, the quarry is in good condition with only minor areas of instability of block failure which are currently mitigated by the catch benches and edge protection bunds. The varying slope and bench configuration around the quarry reflects the varying rock quality and rock mass properties around the quarry.

3.3.2 The benches or access routes around the quarry, while adequate for the current quarry status, are too narrow for the proposed vehicle access, parking, turning, and passing. The HSE guidelines state that the minimum width of a road or ramp within a quarry should be at least 2 times the width of the largest vehicle to use the road. For a two way road, the running width should be 3.5 times the maximum vehicle width.

3.3.3 Edge protection measures should be of sufficient height and construction to prevent the largest vehicle crossing the protection when fully loaded, travelling at the maximum foreseeable speed. The plan dimensions of the edge protection, and any rock fall protection measures on the inside of the road, are additional to the safe road width.

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

4.1.1 WA conclude that the three reports reviewed do not demonstrate that stability has been sufficiently assessed for the proposed development. This conclusion is justified by the following expectations that have not been included in the reports reviewed and which WA consider should have been carried out at this stage to support the planning application:

- A detailed geotechnical risk assessment, either a separate report or a section within a report, providing a risk register of potential hazards to the proposed development, the assessment of the risk of each hazard and the proposed mitigation measures. The geotechnical risk assessment should consider the results of slope stability and kinematic analysis. The geotechnical risk assessment should be reviewed and updated throughout the project.
- A Rock Mass Assessment including Rock Mass Rating (RMR) or Rock Mass Quality Q-System, should have been completed to describe or quantify the rock condition.
- Kinematic assessments to assess the failure mechanisms and determine whether rock fall is likely to be a risk for the proposed development. The geotechnical risk assessment should be updated to identify the rock failure hazards.
- A Rock fall assessment of cut faces for all slopes within Q3. This would determine the potential mitigation measures required to prevent falling rocks landing on the access road or lodges.
- Slope stability analysis on the proposed slope profiles, including the loading effects of the proposed roads, car parking and lodges. Slope stability analysis should be considered for each face and bench as well as the wider site profile. A FoS of 1.5 should be considered as a minimum for permanent slopes within or within influencing distance of the proposed development.
- Provision of, or recommendations for, mitigation measures including rock catchment ditches, spot bolting, rock meshes and slope protection methods which can be determined on the results of the above assessments. Potential

control and mitigation measures should be stated in the risk assessment and a risk rating provided taking these measures into consideration.

- Assessment of the proposed development should be undertaken in accordance with the Quarry Regulations 1999. While strictly speaking these regulations do not apply to a non-operating quarry, they provide best practice and guidance on the geotechnical design of a quarry and its slopes, to ensure the safety of slopes, occupiers and adjacent land.

4.1.2 The Peer Review has assessed the results of the three reports prepared by Abbeydale BEC [1, 2, 3]. The ground investigation was not extensive and intrusive locations were well spread out Q3 [1]. Further testing, such as rock triaxial and tensile strength testing would have been expected to have been carried out to determine the geotechnical input parameters for slope stability analysis. The Overview Site Investigation Report provides a high-level review of the ground investigation and provides Engineering Considerations [2]. WA considers that it does not carry out sufficient risk and geotechnical assessments which would have been expected to be required at planning stage considering the high-risk nature of the site and the sensitivity of the proposed development. The letter report and earthworks sequence [3] does not provide evidence that slope stability has been fully assessed and therefore its conclusions are not sufficiently justified.

4.1.3 It should be noted that since the preparation of the three reports the final lake water level is to be increased to 156m AOD and therefore a review of all the assessments and the proposed development drawings should be carried out.

4.2 Key Considerations not within the scope of the Peer Review

4.2.1 The site visit has identified a number of key considerations outside the scope of this report which are relevant to the proposed development, and which are recommended for further investigation and consideration. These are summarised below:

- Regulations
    - From an initial review, the proposed development would not be subject to the requirements of the Quarry Regulations 1999, however while the construction and earthworks plan is being designed the relevant health and safety and environmental regulations for the site need to be adhered to. The applicability of the Mining Waste Directive and

associated permitting to the proposed materials movement should also be considered.

- Infrastructure
    - There is insufficient geotechnical data to design a bridge to cross between the southern and western lower benches.
    - There is limited available information on the proposed foundation design for the lodges that extend over the lake water, where pile foundations are considered the interaction with the slope would need to be considered.
- Access:
    - The constructability of the proposed access roads, including the delivery of construction materials to build the new roads.
    - The design of proposed road structure including edge protection bunds, requires sufficient road width, passing places and turning circles.
- Q1:
    - Prior to development on tailings and infilled lagoons, sufficient geotechnical investigation and risk assessments should be carried out.
    - Settlement calculations should be carried out for the proposed structures and utilities and demonstrate minimal and tolerable settlement performance.
    - Considerable earthworks are required for the proposed development of Q1. From the three documents reviewed there is insufficient evidence of settlement assessments and the associated conclusions in respect of ground movement.

5 REFERENCES

[1] Abbeydale Building Environment Consultants , “Geotechnical and Hydrological Factual Report Part 1 to 3,” September 2018.

[2] Abbeydale Building Environment Consultants, “Overview Site Investigation Report Moneystone Staffordshire,” October 2018.

[3] Abbeydale Building Environment Consultants, “Q3 - Moneystone Quarry - Safety and Stability Statement,” 05/10/2020.

APPENDICES

APPENDIX A

Abbeydale
Building Environment Consultants

GEOTECHNICAL AND HYDROLOGICAL FACTUAL REPORT

MONEYSTONE QUARRY, OAKAMOOR, STAFFORDSHIRE

Report 418055GR September 2018

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GEOTECHNICAL AND HYDROLOGICAL FACTUAL REPORT

MONEYSTONE QUARRY, OAKAMOOR, STAFFORDSHIRE

Report 418055GR September 2018

DOCUMENT VERIFICATION

	Prepared By	Checked By
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Qualifications:	BSc MSc FGS	BSc MSc FGS C.Geol
Position:	Engineer	MD
Signature:		

SUMMARY

Site Grid Ref:	40440E 34590N	**Site Level (m AOD)**	120 to 190	**Site Area (Ha)**	170
Development proposed:	Outdoor Activity Park				
Past site development:	Moneystone Quarry				
Ground Conditions	**Made Ground:**	Clay slurry in excess of 20m thickness; with a cap of solid mainly granular quarry waste 2m to 4m in thickness.			
	Superficials:	None.			
	Bedrock:	Sandstone over shale dipping 4 to 7 degrees to south			
	Shallowest coal:	No Coal of economic importance identified.			
	Groundwater:	Groundwater encountered within sandstone; plus surface of tailings.			

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GEOTECHNICAL AND HYDROLOGICAL FACTUAL REPORT MONEYSTONE QUARRY, OAKAMOOR, STAFFORDSHIRE Report 418055GR September 2018

1. INTRODUCTION

On the instruction of Bolsterstone plc, on behalf of Laver Leisure, a site investigation was carried out by Abbeydale Building Environment Consultants Ltd on a site to the south of Eaves Lane for an activity park.

The site is located on Moneystone Quarry between the village of Whiston and Oakamoor Village and is centred within National Grid Reference square SK 044 459, at approximately 120m to 170m AOD. See Fig 1. The site covers an area of approximately 170 hectares.

This report was produced on behalf of our client, Laver Leisure and their advisors and financiers, and should not be relied upon or transferred to any other parties without the express written authorisation of Abbeydale BEC Ltd and our client. If any unauthorised third party comes into possession of this report, they rely on it at their own risk and the authors owe them no duty of care or skill.

Abbeydale BEC previously investigated the site in 2011 as part of the larger quarry area, producing the reports listed below. These should be read in conjunction with this report:-

Factual Report	418040GR dated March 2011
Environmental Assessment	418040EA dated March 2011
Desk Study Report	418040DS dated March 2011
Flood Risk Assessment	418040FR dated March 2011

This report covers the factual aspects of the ABEC site assessment and is used as a reference for other reports currently being produced for the Activity Park Development.

The comments and recommendations presented in this report are based on the findings of a review of available information. There may be other conditions prevailing on the site which have not been recorded by the available information and therefore have not been taken into account by this report. Responsibility cannot be accepted for unrecorded information.

When writing this report the proposed development was for an extreme activity holiday park with a central hub, lodges, lakes and lagoons. There will be potential to offer water sports including scuba diving, swimming, sailing, canoeing etc along with fishing. The park will also offer other outdoor activities such as mountain biking, nature trails, climbing, clay pigeon shooting etc. If there are changes to these

proposals, then some modification to the comments and recommendations given may be required.

2. THE SITE

The proposed development is to be constructed on an irregular shaped parcel of land located between the River Churnet which bounds the southern extremity of the site and Eaves Lane which bounds the northern half of the site, trending east-west. The site is accessed off the south side of Eaves Lane via a road which leads to the processing area and carparks. Investigation of the remaining quarry area north of Eaves Lane was not required at the current stage of development, other than determining the suitability of stockpiles of spoil.

The site to be developed has been broadly separated into six main areas, see Fig 2.

A. Quarry 3 (Q3) South - located west side of the main entrance from Eaves Lane.

B. Quarry 1 West (Q1W) / Lagoon 5 (L5) - located on the east side of the main entrance from Eaves Lane.

C. Q3 East, North & West - located on the south side of Eaves Lane, west of the site access road.

D. Hub Area - located to the south of Area B in the quarries former stockpile area just south east of the entrance.

E. Quarry 1 East (Q1E) / Lagoon 4 (L4) - located east of Area B.

L. Located south of Hub and previous quarry processing area.

Other lettered areas previously identified in the quarry are outside the current development and not covered by this report, other than where potential stockpiles of suitable capping materials have been investigated, and present to allow them to be considered for capping Area E. The lower areas south of the processing area, between Area L and the disused railway sidings and River Churnet has currently had no further investigation as no infrastructure is proposed at the current time.

The land surrounding the site is rural with scattered villages, cottages and farms. The primary land use is grazing and hay cutting which has resulted in some herb rich pasture and meadows. The site is directly adjacent to, or contains within, several areas of potentially sensitive landscape features as given below;

Adjacent to the southwest boundary of Quarry 3 is Whiston Eaves Site of Special Scientific Interest (SSSI). The SSSI comprises a series of species rich meadows, managed as grazing pasture or hay meadows. Within the SSSI there are three water courses namely streams A, B and C. As well as the channeled water courses there are several water seepages and springs. Directly north of the SSSI and to the west of Quarry 3 is a Site of Biological Importance (SBI) which is principally improved grass land by grazing cattle.

To the south and east of the site are areas of ancient woodland, the majority of which are replanted.

3. GEOLOGY

The Geological Survey maps of the area, BGS Sheet 124, SK04 NE and SK04NW along with memoir of the area have been examined. Information has also been gained from Geotechnical Assessment (*Reference No. 50*) and Geo-Environmental Desk Study (*Reference No. 49*). The site is shown to be underlain by the Rough Rock Sandstone of the uppermost unit of the Upper Carboniferous Millstone Grit (Namurian) Series, which is overlain by Upper Carboniferous Coal Measures mudstones and siltstones. See Fig. 3.

The Rough Rock Sandstone is fine to medium grained and is composed largely of quartz grains. The sandstone is normally hard and well cemented. However, it does contain beds and lenses of uncemented and poorly cemented weak sandstone. Also present are thin beds or lenses of shale, along with beds of very hard white siliceous sandstone. The sandstone has an on site maximum thickness of 35m, with a typical dip of 5° to 7° and up to 12° south - southwest.

Shale underlies the sandstone and is approximately 2m to 4m below the base of Q1E, Q1W and Q3, see Fig. 4. The site is not underlain by drift deposits whilst residual soil is recorded to be approximately 0.5m thick. Made ground associated with the infilling of the quarry voids is in excess of 20m thick and largely comprises of clay slurry with a cap of 2m to 4m of solid mainly granular quarry waste.

The nearest fault lies near to the eastern boundary of the site called Crowtrees Fault. The fault is trending north - south and has downthrown strata approximately 20m to the west.

Other than the extraction of sandstone there is no known record of any other underground mining methods being employed on or adjacent to the site. A previous report (*Reference No. 49*) indicates that searches with Peter Brett Associates and Ove Arup & Partners mining review data indicate that the site is located in an area of no recorded mining activity.

4. PREVIOUS REPORTS

Numerous reports and letters have been produced about this site since the quarry started production in the early 1960s. A list of the documents examined have been presented within Appendix A - References. From these reports geotechnical data salient to the proposed development has been summarised within the 2011 Factual Report (418040GR).

The data presented in this report produced by others has been reproduced in good faith. In summarising the data and modifying its format, some of the details from the

original data may not have been transposed. It is therefore recommended that if the information is critical to the design or construction proposed the designer or contractor examines the original records referenced and if necessary carry out further investigation to clarify or establish the true conditions present.

5. FIELDWORK

The original 110 exploration records presented in the 2011 Factual Report from the Quarry's archive were produced for varying requirement by the quarry which do not necessarily relate to the currently proposed development. To infill the gaps in geotechnical and environmental information in areas currently proposed for development, a further 116 exploration records have been presented within this factual report. As discussed in Section 2 the site has been divided into eight areas (A to L). Tabulated below is the number of each exploratory hole type conducted in each area. Areas F & I and several additional areas of the estate not listed are outside the area currently being development. In addition to Abbeydale BEC Ltd. logs two percussive holes undertaken by British Industrial Sand Ltd. in 1981 have been appended to Area E.

Area	Exploratory Hole Type				
	Rotary Coring	Cable Percussion	Trial Pit	Window sample	Dynamic Probe
A	2	0	7	0	0
B	0	1	13	17	4
C	1	0	11	7	0
D	0	0	9	7	4
E	0	1	0	10	4
F	0	0	2	2	0
I	0	0	2	1	1
L	0	2	3	4	1

Following the initial closure of quarrying in December 2010 the 23 remaining groundwater standpipes have been monitored quarterly. Additional standpipes from this investigation are being monitored at the same frequency. Additionally as part of the restoration process, water levels in Quarry 3 have been monitored for both standing level and pH, along with stream flow in Streams A, B & C. The results of the monitoring from the most recent quarterly monitoring visit is presented in Appendix D.

Fieldwork was undertaken between January and July 2018 in general accordance with Eurocode 7, BS 5930:2015 and BS 10175. Investigation was achieved using various investigation techniques given below to better understand the ground conditions in the areas of proposed development. The approximate exploration locations are shown on Fig 2. The details of strata encountered are given within the individual logs attached to this report. On completion of site work, disturbed samples were returned to ABEC Ltd office for examination and subsequent testing.

The relative ground levels and positions of the exploratory holes were assessed relative to existing features on site using a tape measure and spot height levels given on the topographical survey by Greenhatch Group, Drawing Ref: 29644_T dated March 2018. See Fig 2.

Trial pits were excavated by a Hyundai Robex 125LCR-9A 360 tracked mechanical excavator with a 0.60m and 0.90m wide toothed bucket to depths of between 0.2m and 6.1m bgl. Additionally in Area C the machine was used to break out the eastern bench of Q3 with a breaker. The trial pits and exposures were logged by our Geotechnical Engineer from the arisings and from examination of the sides and base of the pits from the surface. An assessment of the excavatability of the ground encountered and the stability of the pits was also recorded. Bulk and small disturbed samples were taken at regular intervals. Also several hand pits were dug into existing stockpiles to obtain bulk samples.

Window sample holes were carried out, to depths of between 0.3m and 5.45m bgl, using a tracked window sample rig. Small disturbed samples were taken at regular intervals. In addition, where required, SPTs were carried out at metre intervals using a 50mm split spoon sampler with a 70° taper driven using a 63.5kg hammer dropping through 750mm. The blow counts are recorded for every 75mm driven.

Dynamic probe holes were carried out in accordance with the SRS15 test given in the German Standard DIN 4904. The dynamic probe was driven using a 63.5kg hammer dropping through 750mm, onto 36mm diameter rods driving a superheavy SPT cone. The blow counts are recorded for every 100mm driven (N100) to refusal at depths of between 0.3m and 20.0m bgl.

Two light cable percussion boreholes were advanced to depths of between 17.3m and 17.6m bgl into the lagoon silts of both Q1E (Area E) and Q1W (Area B). Additionally, earlier percussive holes were sunk in 2012 to between 18.4m and 28.4m into the lagoon silts of L3 (Area L). Standard Penetration Tests (SPTs) were carried out in accordance with the method outlined in BS 5930:1999 to provide an indication of the in-situ relative density and consistency of strength for the stratum present and also to obtain samples. During the course of boring, disturbed samples of each stratum were recovered at intervals for identification and classification purposes.

Rotary drill holes were advanced at three locations in Q3 (Areas A & C) to between 5.0m and 17.3m bgl, using an air mist flush and PWF barrels, to recover 85mm diameter cores of bedrock in rigid plastic liners. Cores were extracted from the liner and logged by our engineer in accordance with Eurocode 7 and BS 5930. Point load tests were carried out on selected core samples, see Table 2

Vane testing was undertaken using the Pilcon hand vane tester using a 33mm vane; at depths ranging from 0.2 - 3.2m bgl. Vane tests were carried out in accordance with the method outlined in BS 1377-9.

Plate load tests were conducted in areas B and E in accordance with BS1377-9.

Water and gas monitoring standpipes (32mm diameter) were installed in 18 Exploration holes, with the remainder of the holes backfilled with arisings. Groundwater level monitoring using a hand held dip meter has been undertaken on a quarter year basis and recorded in Table 3b. Historic information from Q2 has not been included within this report.

6. LABORATORY TESTING

Limited geotechnical testing had previously been carried out over the last 30 to 40 years. The materials gain from investigation have therefore been tested to provide additional information on the soil parameters for particular areas of the site where past data is limited. The result certificates have been presented in Appendix B and summarised in Table 1.

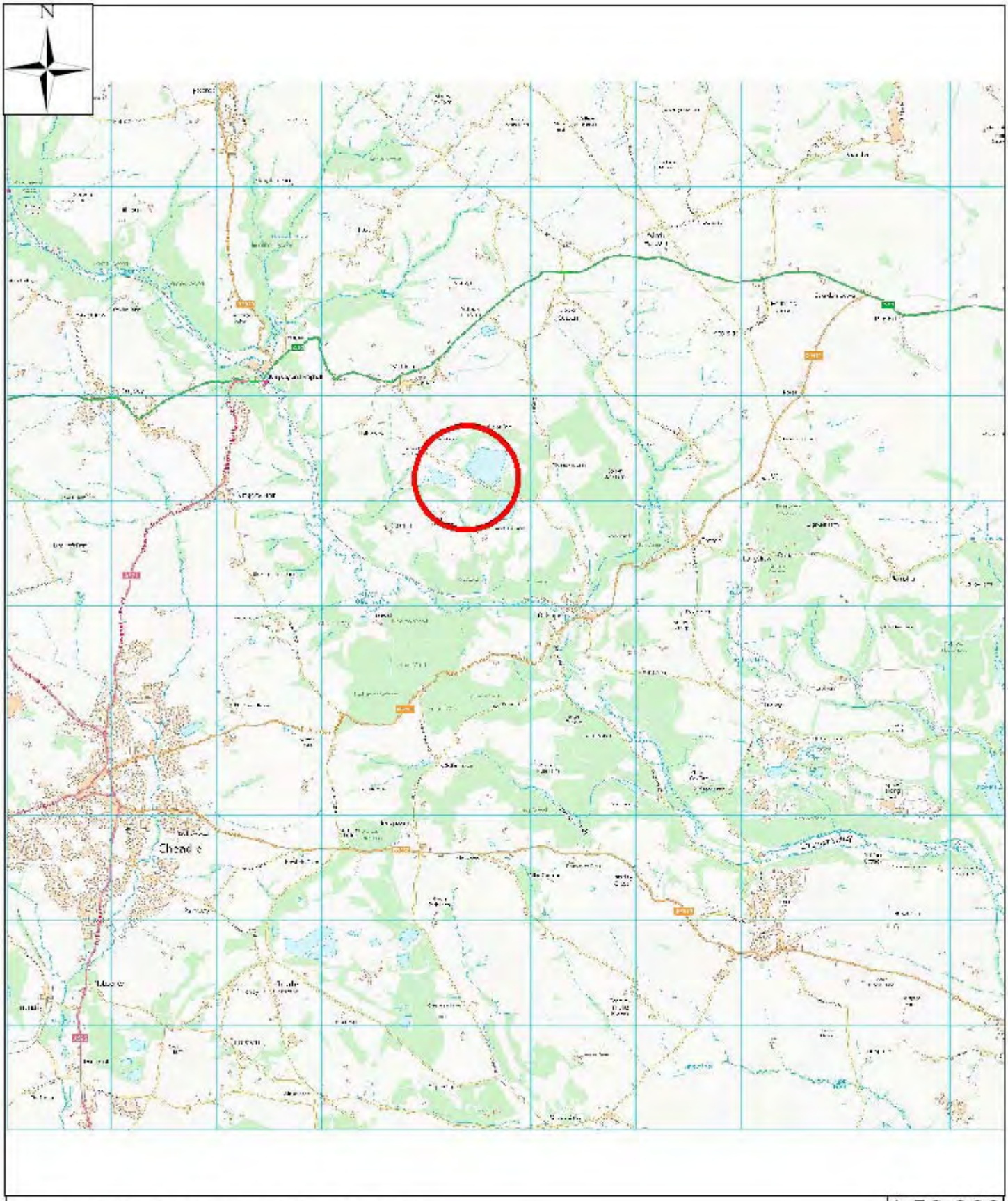
Little reported chemical testing was carried out on site for quarry operations. A groundwater baseline assessment was carried out by Abbeydale BEC and included in Appendix C. As part of this investigation further soil testing on the tailings, solid capping materials and materials proposed for re-use in the development area are presented in Appendix C and summarized in Table 2 (to be added).

7. OTHER GEOTECHNICAL INFORMATION

Exposure logging of the quarry faces has been minimal and presented in general assessment sheets over the quarry's 50 years of operation. Much is specific to the requirements of the quarry at the time and has not been reproduced in this report. Of most use is the exposure logging of the tunnel under Eaves Lane, between Q1 and Q2. The original tunnel log, prepared before rock bolting in January 2002, together a more recent assessment of the tunnel with steriographic projections of the fracturing found are presented in Abbeydale BEC Tunnel Stability Assessment Report 418051TMA dated June 2016. The current investigation exposure logging of the eastern bench of Q3 and selected sections along the northern face have similarly been logged and reported as part of Area C. Further logging is anticipated to be required once development proposals are better known.

The main physical and hydrological features of the site and the surrounding area are discussed in detail within ABEC Desk Study report 418040DS dated March 2011. As part of the quarry restoration monitoring of groundwater has been continued on a quarter year basis and the findings reported in biannual reports 418040MM-2a dated February 2015. The groundwater monitoring, Q3 water levels, stream flow records, and monthly rainfall figures have been reformatted and tabulated within Tables 3b to 5 within this factual report.

Licensed abstractions and discharge have been carried out by the quarry for most of its history. Copies of the most recent licences are given in the appendix of the Abbeydale BEC report GR418040 dated 2011. It is understood that these have not been renewed and with the groundwater levels now recovering in Quarry 3, the licences have been withdrawn. As part of the enabling works a license to discharge into Stream A will need to be considered, and agreement before lowering the outfall, currently at 159m AOD.



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Measurements should not be scaled from this map.

KEY PLAN

Abbeydale
Building Environment Consultants

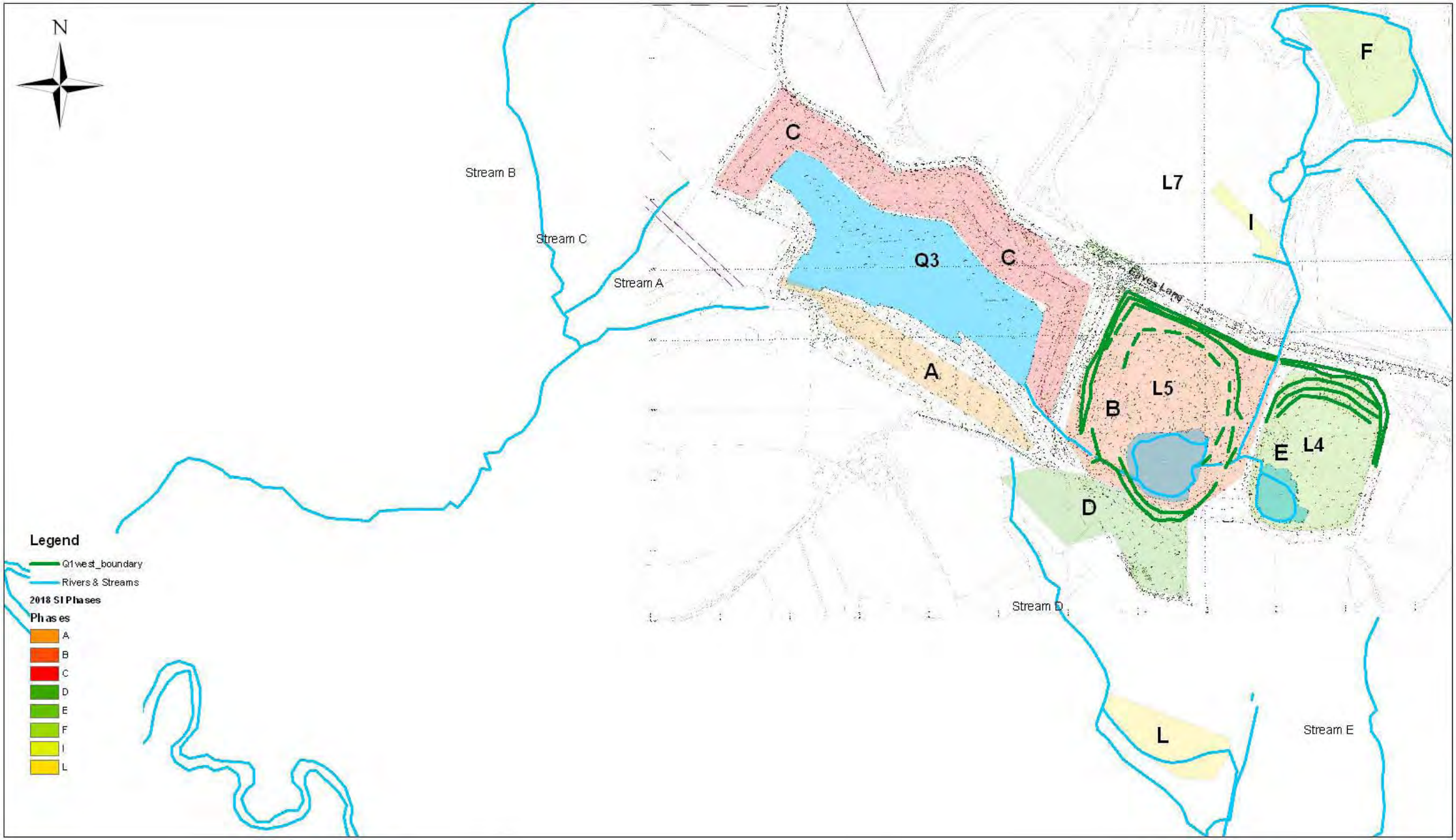
4 Neville Street WF1 5EF Tel: 01924 376622
www.abbeydalebec.com

Site: Moneystone Activity Park

Job No: 418055

Client: Laver Leisure

Fig 1



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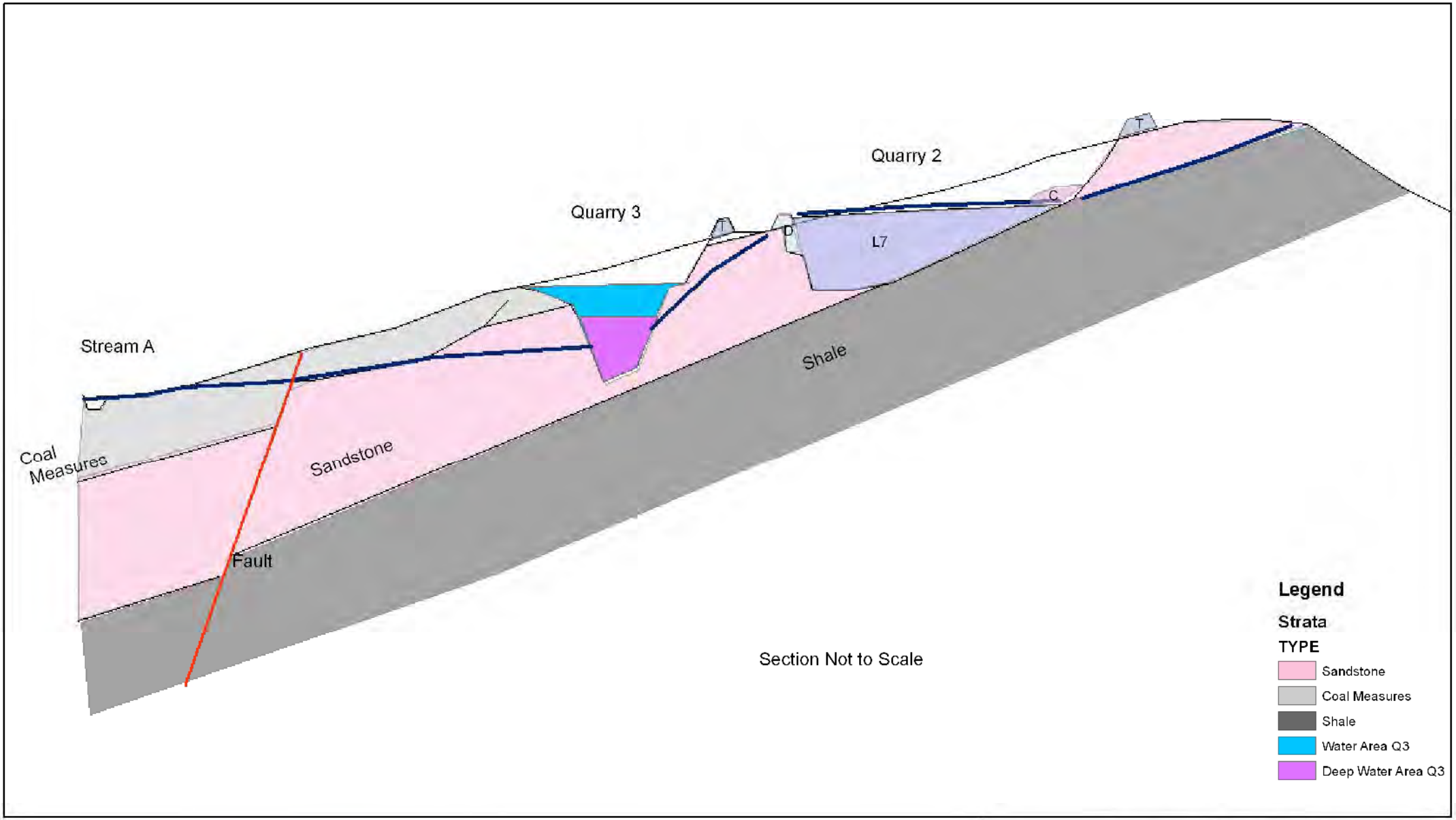
2018 SITE PLAN

Project: Moneystone Park
Job No: 418055
Client: Laver Leisure

Fig 2



Typical Section

Project: Moneystone Quarry Oakamoor
Job No: 418040
Client: Bolsterstone plc
January 2011

Fig. 4

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GEOTECHNICAL AND HYDROLOGICAL FACTUAL REPORT MONEYSTONE QUARRY, OAKAMOOR, STAFFORDSHIRE Report 418055GR September 2018

AREA - A

CONTENTS

Exploratory Hole	Depth (m bgl)	Water Content (%)	Liquid Limit - LL (%)	Plastic Limit - PL (%)	Plasticity Index - IP (%)	Passing 0.425mm (%)	Modified Plasticity - IP' (%)	PSD D_{60}	PSD D_{10}	Dry Density (Mg/m^3)	Bulk Density (Mg/m^3)
A-BH1	11.00	5.7								2.18	
A-TP 1	0.30	18									
A-TP 1	0.80	34	85	35	50	96	48				
A-TP 1	1.30	17									
A-TP 1	2.25	13									
A-TP 2	0.20	26									
A-TP 2	0.40	6									
A-TP 3	0.10	21									
A-TP 3	0.40	10									
A-TP 3	1.20	6									
A-TP 4	0.40	7									
A-TP 4	1.20	5									
A-TP 4	1.50	5									
A-TP 5	0.20	23									
A-TP 5	0.60	18									
A-TP 5	1.20	30	63	28	35	100	35				
A-TP 5	2.50	20									
A-TP 5	2.90	14									
A-TP 6	0.50	12									
A-TP 6	1.80	21	47	22	25	100	25				
A-TP 6	2.80	19									
A-TP11	0.40	24									
A-TP11	1.00	15									
A-TP11	1.30	13									
A-TP11	1.50	9									
A-TP11	2.00	13	41	21	20	77	15.4	100		1.86	

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GEOTECHNICAL RESULTS SUMMARY

Client: Laver Leisure

Project: Moneystone Activity Park SI

Number: 418055

TABLE A1

Point Load Testing of Rock Cores

Abbeydale BEC

ISRM suggested method 1985

Job: **Moneystone (13/02/2018)** Area: A-BH1 & A-BH2 Ram Area A = 1442.1 mm2 **TABLE A2 a**

Job No: **418055**

BH	Depth (m)	Axia (A) / Diametral (D)	Specimen				Gauge Reading G(MN/m2)	Failure Load P (N) G x A	Is (N/MM2) P/De	F (De/50)^0.5	Is 50 N/mm2 F x Is	Is50 x 24 (MN/m2)	Description / Remarks	Strata code	Strength
			Axial (mm)		Diametral (mm)										
			De	Dia	De	L									
A-BH 1	1.98 to 2.07	A	89	80			6.7	9662.1	1.2	1.296	1.58	37.95	PL 9, Planar Fracture	c2	Medium Strong
	1.98 to 2.07	D			61	45	4.1	5912.6	1.6	1.094	1.74	41.71	PL 9, Planar Fracture	c2	Medium Strong
	2.80 to 2.90	A	116	81			5.5	7931.6	0.6	1.460	0.86	20.66	PL 10, Planar Fracture	c2	Weak
	2.80 to 2.90	D			98	45	3.3	4758.9	0.5	1.354	0.67	16.10	PL 10, Planar Fracture	c2	Weak
	3.44 to 3.55	A	118	83			5.6	8075.8	0.6	1.472	0.85	20.49	PL 11, Planar Fracture	c2	Weak
	3.44 to 3.55	D			96	50	3.2	4614.7	0.5	1.341	0.67	16.12	PL 11, Planar Fracture	c2	Weak
	4.20 to 4.30	A	111	82			5.4	7787.3	0.6	1.432	0.90	21.72	PL 12, Planar Fracture	c2	Weak
	4.20 to 4.30	D			58	50	1.6	2307.4	0.7	1.069	0.73	17.60	PL 12, Planar Fracture	c2	Weak
	5.27 to 5.33	A	70	85			3.6	5191.6	1.1	1.163	1.23	29.58	PL 13, Planar Fracture	c2	Medium Strong
	5.27 to 5.33	D			58	45	0.9	1297.9	0.4	1.069	0.41	9.90	PL 13, Planar Fracture	c2	Weak
	6.00 to 6.05	A	52	84			1.5	2163.2	0.8	1.018	0.81	19.54	PL 14, Planar Fracture	c2	Weak
	6.00 to 6.05	D			55	43	1.6	2307.4	0.8	1.044	0.80	19.11	PL 14, Planar Fracture	c2	Weak
	6.05 to 6.14	A	80	83			2.8	4037.9	0.6	1.236	0.78	18.71	PL 15, Planar Fracture	c2	Weak
	6.05 to 6.14	D			63	41	0.9	1297.9	0.3	1.110	0.36	8.71	PL 15, Planar Fracture	c2	Weak
	5.42 to 6.00	A	89	83			2.6	3749.5	0.5	1.296	0.61	14.73	PL 16, Planar Fracture	c2	Weak
	5.42 to 6.00	D			56	35	2.3	3316.8	1.1	1.052	1.11	26.71	PL 16, Planar Fracture	c2	Medium Strong
	11.48 to 11.58	A	108	83			7.4	10671.5	0.9	1.414	1.29	31.05	PL 17, Planar Fracture	c2	Medium Strong
	11.48 to 11.58	D			58	51	3.4	4903.1	1.5	1.069	1.56	37.40	PL 17, Planar Fracture	c2	Medium Strong
	11.38 to 11.48	A	94	84			6	8652.6	1.0	1.329	1.30	31.22	PL 18, Planar Fracture	c2	Medium Strong
	11.38 to 11.48	D			59	47	3.6	5191.6	1.5	1.077	1.61	38.56	PL 18, Planar Fracture	c2	Medium Strong
	11.29 to 11.38	A	99	83			5.3	7643.1	0.8	1.360	1.06	25.45	PL 19, Planar Fracture	c2	Medium Strong
	11.29 to 11.38	D			56	45	2.8	4037.9	1.3	1.052	1.35	32.52	PL 19, Planar Fracture	c2	Medium Strong
	11.15 to 11.35	A	101	84			6.6	9517.9	0.9	1.372	1.28	30.73	PL 20, Planar Fracture	c2	Medium Strong
	11.15 to 11.35	D			56	48	2.8	4037.9	1.3	1.052	1.35	32.52	PL 20, Planar Fracture	c2	Medium Strong
	8.40 to 8.50	A	117	85			5.5	7931.6	0.6	1.466	0.85	20.39	PL 21, Planar Fracture	c2	Weak
	8.40 to 8.50	D			98	50	2.8	4037.9	0.4	1.354	0.57	13.66	PL 21, Planar Fracture	c2	Weak
	8.80 to 8.89	A	93	84			4.1	5912.6	0.7	1.322	0.90	21.69	PL 22, Planar Fracture	c2	Weak
	8.80 to 8.89	D			59	38	1.9	2740.0	0.8	1.077	0.85	20.35	PL 22, Planar Fracture	c2	Weak
	8.96 to 9.05	A	103	85			2.3	3316.8	0.3	1.384	0.43	10.39	PL 23, Planar Fracture	c2	Weak
	8.96 to 9.05	D			51	50	1.4	2018.9	0.8	1.009	0.78	18.80	PL 23, Planar Fracture	c2	Weak
	10.23 to 10.33	A	102	84			3.5	5047.4	0.5	1.378	0.67	16.05	PL 24, Planar Fracture	c2	Weak
	10.23 to 10.33	D			77	50	2.5	3605.3	0.6	1.214	0.74	17.72	PL 24, Planar Fracture	c2	Weak

Point Load Testing of Rock Cores

Abbeydale BEC

ISRM suggested method 1985

Job: **Moneystone (13/02/2018)** Area: A-BH1 & A-BH2 Ram Area A = 1442.1 mm2 **TABLE A2 a**

Job No: **418055**

BH	Depth (m)	Axia (A) / Diametral (D)	Specimen				Gauge Reading G(MN/m2)	Failure Load P (N) G x A	Is (N/MM2) P/De	F (De/50)^0.45	Is 50 N/mm2 F x Is	Is50 x 24 (MN/m2)	Description / Remarks	Strata code	Strength
			Axial (mm)		Diametral (mm)										
			De	Dia	De	L									
A-BH 2	1.80 to 1.86	A	64	82			0.9	1297.9	0.3	1.117	0.35	8.50	PL1, Planar Fracture	c2	Weak
	1.80 to 1.86	D			60	25	0.7	1009.5	0.3	1.086	0.30	7.31	PL1, Planar Fracture	c2	Weak
	3.26 to 3.35	A	94	80			1.4	2018.9	0.2	1.329	0.30	7.29	PL2, Planar Fracture	c2	Weak
	3.26 to 3.35	D			66	40	1.1	1586.3	0.4	1.133	0.41	9.90	PL2, Planar Fracture	c2	Weak
	3.90 to 3.41	A	118	80			1.7	2451.6	0.2	1.472	0.26	6.22	PL3, Planar Fracture	c2	Weak
	3.90 to 3.41	D			50	50	0.8	1153.7	0.5	1.000	0.46	11.08	PL3, Planar Fracture	c2	Weak
	4.85 to 5.96	A	108	80			8	11536.8	1.0	1.414	1.40	33.57	PL4, Planar Fracture	c2	Medium Strong
	4.85 to 5.96	D			63	40	3.6	5191.6	1.3	1.110	1.45	34.83	PL4, Planar Fracture	c2	Medium Strong
	2.45 to 3.55	A	102	80			6	8652.6	0.8	1.378	1.15	27.51	PL5, Planar Fracture	c2	Medium Strong
	2.45 to 3.55	D			50	45	3.4	4903.1	2.0	1.000	1.96	47.07	PL5, Planar Fracture	c2	Medium Strong
	3.35 to 3.45	A	100	83			6.8	9806.3	1.0	1.366	1.34	32.15	PL6, Planar Fracture	c2	Medium Strong
	3.35 to 3.45	D			57	50	3.1	4470.5	1.4	1.061	1.46	35.03	PL6, Planar Fracture	c2	Medium Strong
	4.0 to 4.12	A	122	82			6.3	9085.2	0.6	1.494	0.91	21.89	PL7, Planar Fracture	c2	Weak
	4.0 to 4.12	D			50	60	3.2	4614.7	1.8	1.000	1.85	44.30	PL7, Planar Fracture	c2	Medium Strong
	4.75 to 4.87	A	124	82			9	12978.9	0.8	1.505	1.27	30.49	PL8, Planar Fracture	c2	Medium Strong
	4.75 to 4.87	D			98	55	4.7	6777.9	0.7	1.354	0.96	22.93	PL8, Planar Fracture	c2	Weak

Point Load Testing of Rock Cores

Abbeydale BEC

ISRM suggested method 1985

Job: **Moneystone (30-10-2015)** Area A Ram Area A = 1442.1 mm2 **TABLE A2 b**

Job No: **418055** Calibration Factor (N) = 0.7463

	Sample No.	Axia (A) / Diametral	Specimen				Gauge Reading	Failure Load P	Is (N/MM2)	F	Is 50 N/mm2	Is50 x 24 24	Strata code	Strength
			Axial (mm)		Diametral (mm)									
		(D)	De	Dia	De	L	G(MN/m2)	(N) G x A	P/De	(De/50)^0.45	F x Is	(MN/m2)		
	B32	A	45	103			2.5	2690.5	1.3	0.954	1.27	30.41	S	Medium Strong
		A	42	101			2.3	2475.2	1.4	0.925	1.30	31.14	S	Medium Strong
		A	40	80			1.6	1721.9	1.1	0.904	0.97	23.36	S	Weak
		A	41	57			0.9	968.6	0.6	0.915	0.53	12.65	S	Weak
	A32	A	46	110			3.4	3659.1	1.7	0.963	1.67	39.97	S	Medium Strong
		A	44	88			2.4	2582.9	1.3	0.944	1.26	30.23	S	Medium Strong
		A	55	81			3.0	3228.6	1.1	1.044	1.11	26.74	S	Medium Strong
		A	48	65			1.5	1614.3	0.7	0.982	0.69	16.51	S	Weak
		A	58	50			2.4	2582.9	0.8	1.069	0.82	19.70	S	Weak
		A	37	41			2.1	2260.0	1.7	0.873	1.44	34.60	S	Medium Strong
		A	40	41			2.5	2690.5	1.7	0.904	1.52	36.50	S	Medium Strong
	A33	D			118	105	3.5	3766.7	0.3	1.472	0.40	9.55	S	Weak
		A	46	66			5.4	5811.4	2.7	0.963	2.65	63.49	S	Strong
		A	42	40			3.7	3981.9	2.3	0.925	2.09	50.09	S	Strong
		A	26	90			2.3	2475.2	3.7	0.745	2.73	65.48	S	Strong
	B33	A	58	123			1.5	1614.3	0.5	1.069	0.51	12.31	S	Weak
		A	49	31			1.5	1614.3	0.7	0.991	0.67	15.99	S	Weak
		A	64	42			1.1	1183.8	0.3	1.117	0.32	7.75	S	Weak
		A	58	50			1.2	1291.4	0.4	1.069	0.41	9.85	S	Weak
		A	45	54			0.9	968.6	0.5	0.954	0.46	10.95	S	Weak
		A	64	23			0.8	861.0	0.2	1.117	0.23	5.64	S	Weak
	B33	A	80	135			6.2	6672.4	1.0	1.236	1.29	30.91	S	Medium Strong
		A	79	40			3.3	3551.4	0.6	1.229	0.70	16.78	S	Weak
		A	76	25			2.8	3013.3	0.5	1.207	0.63	15.12	S	Weak
		A	64	37			4.0	4304.8	1.1	1.117	1.17	28.19	S	Medium Strong
		A	77	82			3.4	3659.1	0.6	1.214	0.75	17.99	S	Weak

Point Load Testing of Rock Cores

Abbeydale BEC

ISRM suggested method 1985

Job: **Moneystone (30-10-2015)** Area A Ram Area A = 1442.1 mm2 **TABLE A2 b**

Job No: **418055** Calibration Factor (N) = 0.7463

	Sample No.	Axia (A) / Diametral (D)	Specimen				Gauge Reading G(MN/m2)	Failure Load P (N) G x A	Is (N/MM2) P/De	F (De/50)^0.45	Is 50 N/mm2 F x Is	Is50 x 24 24 (MN/m2)	Strata code	Strength
			Axial (mm)		Diametral (mm)									
			De	Dia	De	L								
		A	77	35			2.8	3013.3	0.5	1.214	0.62	14.81	S	Weak
	A31	A	76	101			4.0	4304.8	0.7	1.207	0.90	21.60	S	Weak
		A	89	50			2.4	2582.9	0.3	1.296	0.42	10.14	S	Weak
		A	79	58			2.4	2582.9	0.4	1.229	0.51	12.20	S	Weak
		A	85	49			2.5	2690.5	0.4	1.270	0.47	11.35	S	Weak
		A	105	72			1.7	1829.5	0.2	1.396	0.23	5.56	S	Weak
		A	77	42			2.4	2582.9	0.4	1.214	0.53	12.70	S	Weak
		A	74	65			2.3	2475.2	0.5	1.193	0.54	12.94	S	Weak
	B31	A	95	100			4.5	4842.9	0.5	1.335	0.72	17.19	S	Weak
		A	65	95			3.8	4089.5	1.0	1.125	1.09	26.14	S	Medium Strong
		A	84	95			5.8	6241.9	0.9	1.263	1.12	26.81	S	Medium Strong
		A	88	85			5.0	5381.0	0.7	1.290	0.90	21.51	S	Weak